HIGHLIGHTS IN HERPETOLOGY: IT'S NOT ALL SNAKES

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When Father Schmelz contacted me regarding a title for this address, I must have been mildly annoyed with someone who thought that herpetology is only the study of snakes. I suppose I should have been grateful that anyone knows that much about what a herpetologist is and does. Long ago when I was beginning my study of the amphibians and reptiles of Indiana, I saw the name of a physician who had been practicing in New Albany about the turn of the century listed as collector of a rather unusual snake in a museum collection. He had died about the time I was born, but New Albany is my home town, and I wrote to one of his relatives, a nice, middle-aged lady, saying that I didn't know her uncle had been a herpetologist and did she know what had happened to his collections? She replied that the doctor knew a lot about herbs because he made up many of his own medicines, and maybe I should be more careful with my spelling.

What I want to share with you are some stories from the lives of amphibians and reptiles that have intrigued me and I hope will be of interest to other members of the Academy. The first of these begins in 1827 when Jacob Green described a rather ordinary looking bluish-grey salamander from the campus of Jefferson College in Pennsylvania giving it the name *Salamandra jeffersoniana* or Jefferson's salamander. For the next hundred years, nothing very exciting happened concerning this salamander. It proved to be one of the commoner salamanders of the northeastern United States and ranged north in eastern Canada about as far as a salamander can survive. Like many wide-ranging animals, it showed considerable geographic variation. Some workers split it into several species, while others lumped it into one. It was removed from the genus *Salamandra* and put in the genus *Ambystoma*, and the general features of its life history were learned. Jefferson's salamander is almost unique among northeastern salamanders in being a winter breeder. Almost any time after the first of the year that there are two or three days of temperatures in the 40s or 50s accompanied by rain or heavy snow melt, these salamanders will emerge from their burrows and move to shallow ponds in woods or at the edge of woods. In the ponds, males and females find each other, and there is a courtship ritual in which the two rub and nuzzle each other until the male deposits a conical spermatophore on a twig or leaf, and the female pinches off the cap of sperm between the lips of her vent. Males may deposit as many as twenty spermatophores, and each female will pick up perhaps a half dozen, so there are usually a good many left over. In most years, the salamanders remain a month or so in the ponds and later are joined by two or three related species which have a similar breeding pattern, although the courtship rituals differ. After fertilization, females lay clumps of eggs encased in jelly. These hatch as the water warms, and the larval salamanders transform into adults about the end of May or early June in the midwest.

The first person to notice that there was something unusual about the life history of Jefferson's salamander was Wesley Clanton, a University of Michigan zoologist, who was studying the species near Ann Arbor about 1930. He found the population here consisted of "two confusingly similar forms" that he designated as dark and light. Moreover, the light form consisted entirely of females. These females mated with dark males to produce more females. In some sites this led to a highly unbalanced sex ratio that Clanton felt would result in extinction of both forms. However he did not follow up his observations, and things rested there for almost twenty years. About 1950 I came briefly into the picture because I was working on the herpetology of Indiana. At that time I knew Jefferson's salamander from the populations around New Albany where they looked very much like the animal Green described from Pennsylvania and from the Indiana Dunes and Jasper-Pulaski State Forest where they were smaller and darker with prominent blue-white flecks. Both populations had a reasonable proportion of males to females. As I accumulated more material, I found intermediate individuals, nearly all of them females from north of Indianapolis. Eventually I concluded that the dark, blue-flecked northern form was a distinct species for which I revived the old name *Ambystoma laterale*. I speculated that hybridization between *jeffersonianum* and *laterale* produced only females, a situation that seemed to hold little future for the hybrid populations, since a growing number of females would be competing for an ever decreasing number of males.

The next really big advance came about 1960 when another University of Michigan scientist, Thomas Uzzell, did a great deal of field and laboratory work on these salamanders and came up with some interesting conclusions. One was that the all-female populations had a triploid number of chromosomes instead of the diploid number normal in sexually reproducing organisms. Also these triploids seemed to be of two types, one, to which he applied the name *platineum*, was similar to *Ambystoma jeffersonianum* and the other, given the name *tremlayi*, was very similar to *A. laterale*. He found that the mode of reproduction in these triploids is gynogenesis in which sperm are necessary to initiate development of the eggs but contribute nothing genetically. He reasoned that the sperm would probably come from one or the other of the related diploid species, since males of unrelated species would probably not court the triploid females nor would the females be stimulated to pick up spermatophores of males of unrelated species.

Since Uzzell's work in the 60s the problem has become more complicated. As Uzzell and I collected in Indiana ponds where triploid salamanders were found, very rarely did we find males of either related diploid species, but we always found good numbers of males of some ambystomid salamander, usually the smallmouth salamander, *Ambystoma texanum*. This is a rather nondescript salamander not too different in appearance from animals of the *jeffersonianum* complex. But in some other ponds the triploids were found only with the spotted salamander (*Abmystoma maculatum*) which is quite different in appearance and courtship behavior. And, although it has not been proved, it seems very likely that the triploids are using sperm of unrelated ambystomid salamanders to initiate development of their eggs. If this is not the case, then true parthenogenesis must be occurring. More recently there have been reports of diploid eggs being found in egg masses laid by triploid salamanders and of true hybrids between salamanders of the *jeffersonianum* complex and the smallmouth salamander which may itself be a composite of two species. It looks like there is material here for midwestern zoologists to work on for quite some time.

Going from small woodland amphibians to very large marine reptiles, I want next to say something of the wanderings of sea turtles. There are seven species of sea turtles. All are large and have breeding ranges in the tropics or subtropics. They are the most commercially valuable of reptiles and are variously utilized for meat, eggs, shell, leather, and oil. There are entire island and maritime communities whose culture and economy is as closely linked to the sea turtle as ours is to the automobile. And, particularly in the last century, sea turtles have been badly over exploited. Only comparatively recently have we become aware of this, and efforts to reverse the trend are just beginning to show some success. In order to protect the turtles, it has been necessary to learn a great deal about their biology, particularly their movements to and from nesting grounds. Adult turtles are fairly easy to mark, usually by putting a metal tag on the front flipper, and thousands have been tagged at nesting grounds. Through the recovery of tagged turtles, we are slowly learning something of their wanderings.

As they leave the water to nest, female turtles leave their signature on sandy beaches throughout the tropics, although not in the numbers they did a century or two ago. There are two main stages to nesting, first construction of a large, shallow body pit by strong sweeps with the fore flippers and second the digging of the small, deep egg pit with the hind flippers. Once the second stage has begun, nothing short of dynamite will deter the female from her task. After nesting, the female returns to the sea where she often mates with males that have followed her to the nesting beach. A female may lay two or three clutches of eggs in a season, but it appears that no species nests annually. Most seem to be on a two or three year cycle with the possibility of a four year cycle for some. Several species of turtles may use the same nesting area.

Most of the information we have about sea turtles is based on the green turtle, *Chelonia mydas*; however, the broad pattern seems similar for all species. Although turtles of all species show great fidelity to nesting grounds, only the green seems to have well defined feeding grounds as well. This may be because it is the only species that is wholly an herbivore as an adult. The migration between feeding and nesting grounds may be long or fairly short. One of the longest and most interesting migrations is made between feeding grounds along the bulge of Brazil and nesting grounds at Ascension, a tiny island about half way between South America and Africa. An Air Force song of World War II had a line that went, "If you miss Ascension, your wife gets a pension." indicating that even with modern navigational equipment the island wasn't the easiest place to find. But the turtles find it, and they make the trip out and back without eating. Moreover, the baby turtles somehow find their way back to the coasts of South America where they mature. Other green turtles that feed along the Brazilian bulge make a long migration along the north coast of South America to nest on Surinam beaches. All studies indicate these turtles never nest at Ascension, nor do Ascension turtles ever nest at Surinam. The well studied green turtle population at Tortuguero on the Atlantic side of Costa Rica migrates for the most part only a short distance to feed along the Mosquito Coast of Nicaragua, but occasional marked turtles from this population have been found throughout the Caribbean.

The leatherback (*Dermochelys coriacea*) is the largest of sea turtles, indeed the largest of living reptiles if only weight is considered; record specimens may reach about 500 kg. Its shell is not a massive bony structure but rather a mosaic of many small bones embedded in a thick skin. The form is beautifully streamlined with seven low ridges on the upper side and five below. The leatherback also has the widest range of any reptile. Although most of its breeding sites are within the tropics, there are about 200 sightings or captures of leatherbacks in northern European waters from Iceland to well above the Arctic Circle off the north tip of Norway. There are some 88 records for New England and Canadian waters. In the north Pacific, records go from the Gulf of Alaska to the northernmost islands of Japan. There are fewer records from the far southern seas, but this may only mean there are fewer observers there. Data from tagged leatherbacks indicate that their dispersal from nesting beaches seems to be random. The most remote spots from home base that turtles tagged at Surinam beaches have been found are the coasts of Ghana and New Jersey. In each case, the trip took about a year.

In the Atlantic, loggerheads (*Caretta caretta*) are recorded about as far north as leatherbacks, but there are far fewer sightings. I am not so sure now as I was a few years ago that these leatherbacks and loggerheads sighted in far northern or southern seas often make it back to the tropics. The leatherback has a mechanism, not altogether understood, for keeping its core temperature as much as 17°C. above that of the sea. It is also known that a water temperature of about 11°C. is very likely to be lethal to these turtles. So if they get into northern waters, they had better get back before the temperature falls to this critical point. We have no idea how many do. A recent report of activities of leatherbacks and loggerheads off the coast of Florida as observed from a spotter plane indicated that the turtles in August seemed to be avoiding the Gulf Stream as though they did not want to be carried north by its current.

We still have no good idea how sea turtles navigate. Another and probably related puzzle is the so-called lost year of the baby turtle. The baby turtles, 80 to 100 to a nest, literally erupt from the sand about sixty days after the eggs are laid. Hundreds are destroyed by crabs and other predators before they ever reach the water, and doubtless many others are eaten soon after they enter the sea. But there comes a time soon after the young turtle gets to the sea that it just literally disappears. There are almost no specimens of small turtles from hatchling size to the size that we estimate from growth of captives to be that of a yearling, and most of those that do exist were taken from stomachs of predators such as sharks. However, what we think happens is that baby turtles swim very vigorously away from the shore until they are picked up by a current, and probably presence of favorable currents is one thing that determines if a beach will be a good one for turtle nesting. Then they are carried passively by the current for a great distance. As the baby turtle drifts, its brain is storing countless bits of chemical and physical data about each current and perhaps surprisingly unique to it. When the time comes for the turtle to return to the waters of its birth, it calls on this store of information to guide it back. Turtles also have a sun compass sense as many cold-blooded vertebrates do, and there is some evidence they may orient with the earth's magnetic field. But we still have a great deal to learn about sea turtle navigation, and about sea turtles generally.

Finally I want to talk about lizards and snakes, and more specifically about some novel ways these reptiles use their tails. Many vertebrates use the tail as an aid in locomotion, in swimming, climbing, flying, jumping and running; lizards and snakes use it for locomotion, too, but they may do other things as well. Anyone who has tried to catch small lizards learns that they readily sacrifice their tail to a pursuer. The broken tail vigorously writhes and twists, distracting the hunter and often allowing the lizard to escape. The tail is rather promptly regenerated, the new tail generally being less perfect than the original. Sometimes a forked tail or one with several branches is produced.

In some other lizards, the tail is heavy, firmly attached, and spiny, making it an uncomfortable object for a potential predator to grasp. It is curious the way this adaptation crops up sporadically in unrelated groups of lizards. It is seen among the sungazers (*Cordylus*) a family endemic to southern Africa, the mastigures (*Uromastix*) of the Afro-Asian desert belt that are members of widespread agamid family, the spiny-tailed iguanas (*Enyaliosaurus*) of Mexico, again a member of a widespread family, and in a few Australian species of the cosmopolitan skink family.

Another use of the tail in defense is that of the varanids or monitors. These large Old World lizards use their tail actively as a whiplash. A monitor about a meter long can give a stinging blow, and larger ones have been reported to disable dogs in this manner.

A very strange tail defense is used by a few small Australian geckos of the genus *Diplodactylus*. If they are injured or severely threatened, they eject from their tail strands of a material rather like spider silk. First reports indicated the material came from the prominent rows of papillae on the tail; actually it comes from cracks between the papillae. Although this is obviously a defensive tactic, it is by no means clear how the material affects a possible enemy. One group of scientists put some of the material on mealworms and offered them to chicks. The chicks didn't seem to like the worms as well as untreated ones, but there was no evidence the substance was toxic or even highly distasteful. I smelled the secretion and put a bit on my tongue. It had a faint odor rather like crushed maple leaves, and there was no taste at all. I have but one rather wild speculation as to how and against what it may be used. These lizards live under the bark of standing trees. The bark must be loose enough that the lizards can move about but not so loose that they are vulnerable to snakes, birds and other predators. The same habitat is used by large flat spiders the Australians call "huntsmen". These spiders could probably kill even the adult geckos and could certainly eat the young ones. In the cramped quarters of their habitat I can imagine these silky strands entangling or impeding a spider enough that the gecko might escape.

Lizards may engage in threat displays that involve use of the tail. In the case of the fat-tail gecko (*Eublepharis macularius*) of southwest Asia, the lizard rises high on its legs, arches its back, and waves its tail about rather like a scorpion preparing to sting. It may also open its mouth and make an odd noise something between a squeal and a hiss. In Pakistan this gecko, known as "hun-khun", was the most feared of reptiles. Its bite or contact with any of its body fluids were said to be instantly fatal.

In our western deserts probably the speediest lizards are species of the genera *Callisaurus* and *Holbrookia*. They dart almost too fast for the eye to follow across the flat, bare soil, stop suddenly and flatten their body, becoming practically invisible. And then, for no apparent reason, they will often raise the tail, showing the conspicuously banded black-and-white undersurface and wave it slowly about almost as though they were inviting attention. Then they will streak off again usually in a different direction. In Baluchistan I saw a toad-headed lizard (*Phrynocephalus maculatus*) do something rather similar. I found these lizards only in an area that was flat and incredibly barren—there was literally no place for a lizard to hide. They usually sat on rocks, and as you approached them they would curl the tail in a spiral and slowly lash it back and forth. Then they would run and flatten against the soil, but they did not then elevate the tail as the American lizards do.

Tail displays are common among snakes. Several species of coral snakes when disturbed will thrash about with the tail elevated and the tip curled on itself so that it looks somewhat like the head. Another venomous snake, *Maticora bivirgata* of southeast Asia, does much the same thing. In this species, both head and tail are bright orange and the body blue-black. Western subspecies of the ringneck snake (*Diadophis punctatus*) when alarmed often go into elaborate contortions in which the tail is curled into a tight spiral showing the undersurface which is bright red in contrast to the yellow or orange belly.

Using the tail for sound production reaches its acme in the rattlesnakes. They seem to be taking special advantage of an old and widespread serpent habit of vibrating the tip of the tail when alarmed. In a suitable medium such as dry leaves this can make a distinctive sound. I once thought that this trait in such nonvenomous snakes as rat snakes and king snakes was an attempt to imitate the rattlesnake, however it shows up in many parts of the world where there are no rattlesnakes to imitate.

Curiously enough, in the deserts of southwest Asia is a lizard that uses its tail for sound production. It is a medium-size gecko (*Teratoscincus scincus*), and it makes a sound by undulating its tail in such a way that the large plates on its dorsal surface rasp against each other. The sound is a very faint one, and I missed it on my first encounter with this strange reptile. But it can be heard under the right conditions. Again, I can only speculate what benefit it is to the lizard to make this sound. In the great sand dunes of Baluchistan, *Teratoscincus* lives with a deadly little snake, the saw-scaled viper, that has its own curious method of sound production. It inflates its body with air and rubs loops together so that the serrate scales make a sizzling sound. The sound the lizard makes is similar but much fainter, however in a burrow or underground cavity it might be enough to frighten an enemy.

Another function of the tail is fat storage. This is seen most frequently in lizards that live in desert areas and exist on a feast or famine regimen. The gila monster of our Southwest is a good example. The closely related Mexican beaded lizard does not have such a fat tail, apparently because it lives in a more mesic region. The uncommon little gecko *Teratolepis* of the Sind Desert in Pakistan is another species that stores fat in its tail as does the wood gecko (*Diplodactylus vittatus*) of eastern Australia. Tails of these fat-tail geckos usually break only at the base, so the small predator that seizes one gets a fair meal for its effort. The regenerated tail often becomes more bulbous than the original. The shingleback (*Trachydosaurus rugosus*) is a large, slow, armored Australian skink whose stumpy tail can be almost as large as its head, and it really is hard to tell at a glance which end is which. This could serve to misdirect the attack of an enemy. Some small sand boas of the genus *Eryx* may use the thick, blunt tail to divert an attacker. I saw this illustrated quite graphically one night when collecting in the Sind desert. A sand boa about 70 cm long lay in a tight coil, its tail chewed raw and bleeding. Tracks showed it had been attacked by a fox or small jackal. Had the animal seized its head, the snake would almost certainly have been killed; as it was, it suffered only trivial injury.

I saw a West Indian dwarf boa (*Tropidophis*) use this defense when threatened, making a compact coil that hid its head but left the tail exposed. This snake does not have a particularly blunt tail, but the tip is pale orange and constrasts strongly with the body color. I suspect that this species may use its tail in another way that is well known among snakes but has not been described for lizards, namely as a lure for prey. Most of the snakes that are known or suspected to use tail-luring are venomous species that strike from ambush and feed on lizards, frogs, and perhaps small birds. The conspicuous tail tip presumably resembles a grub or other insect larva. In most species, only young snakes use tail-luring. Raymond Ditmars was one of the first to describe how new-born copperheads wiggled the yellow tips of their tails when small frogs were put in their cage. The cantil, a Central American relative of the copperhead, holds its tail upright to make the light tip more conspicuous. The late Ross Allen described how frogs were attracted by the lure and even sometimes bit it before the snake caught them. Toads were also attracted, but the snakes would not attack them. In the dangerous Central American pit viper *Bothrops asper* (one of several species known as fer-de-lance) only the young males have yellow tail tips, and luring has not been observed

Young males of the Saharan sand viper (*Cerastes vipera*) have yellow tail tips and females black; the significance of this is unknown.

The heavy-bodied Australian death adder belongs to the elapid or cobra family but looks for all the world like a viper. It too has a tail lure, in fact it has the most elaborate tail lure I have seen. The tip of the tail is slightly widened and flattened, the scales are arranged to simulate segments, and the color is yellow with a few light and dark flecks. The resemblance to an insect larva is surprising. For several months I had a death adder in a glass cage near my desk. When the snake was hungry, it raised its tail displaying the lure. I could not determine if it attracted prey; if I dropped a lizard in the cage, the snake seized and swallowed it at once. As I watched this snake, I wondered if perhaps a similar tail lure was not once on a pit viper with the habit of tail vibrating. For one reason or another, sound production served the species better than luring prey, and, given a few million years of selection pressures, the rattle of the rattlesnakes evolved.

Returning to lizards, tail shape, size, and color may be important in social interactions. Recent work indicates that individuals of the little side-blotch lizard (*Uta stansburniana*) of our western states lose their place in the social hierarchy if they lose a third or more of their tail. Another study indicates that the bright blue tails characteristic of many young skinks of North America and eastern Asia inhibit aggressive behavior by adult males of their own species. To confuse things, there are young skinks in Australia, Asia, and the western United States that have red or orange tails, and a little sandburrowing species in Florida has a tail that may be blue, orange, brown or violet. In other lizard families such as the anoles there are tail crests and other ornaments that probably help in defending territory and selecting mates. Lizard ethology is a whole different game with the players frisking about in sunny spots on six continents. I recommend them for your study and enjoyment.