Natural History of Vertebrates
Lecture Notes
Chapter 10 - Salamanders, Anurans, and Caecilians

These notes are provided to help direct your study from the textbook. They are not designed to explain all aspects of the material in great detail; they are a supplement to the discussion in class and the textbook. If you were to study **only** these notes, you would not learn enough to do well in the course.

Be sure to study the List of Terms

Extant Amphibians

The extant amphibians include three lineages (salamanders, frogs, and caecilians). They are probably a monophyletic group (figure 9-1) separate from the other tetrapods, though possibly the caecilians evolved from the Lepospondyli Generally, they have smooth skin and lack scales. The skin is kept moist and all species exchange at least some gases through the skin (cutaneous respiration). All are carnivorous and will eat whatever comes within range that is not too big. The oldest fossils are from the Permian and clear fossils from all three modern lineages are known from the Jurassic.

Salamanders (Urodela, figure 10-1, table 10-2)

- 8 families, 556 species
- They have a generalized body plan (elongate body with four limbs of about equal size).
- Walking involves an anguillaform motion of the body while moving the legs forward.
- Swimming is an anguillaform motion of the entire body
- Several have adapted to life in caves
- Many are paedomorphic and retain such larval characteristics as external gills, lateral line system, no eyelids, and larval tooth patterns as adults. There forms are fully aquatic.
- Some plethodontids are completely terrestrial and lay an egg in which the larval stage is completed before hatching.

The **plethodontids** are one of the best known of the salamander families and this groups has some rather interesting specializations.

This group of salamanders has lost its lungs. Respiration is wholly through the skin. The loss of lungs has allowed this groups of salamanders to develop a tongue which can be projected at prey items (figure 10-2). All salamanders lack ribs and thus to get air into the lungs must use a buccal pump, where air is held in the mouth and then compressed to move it into the lungs. This buccal pump uses several muscles that are attached to the tongue. Thus plethodontids had to give up breathing through their lungs so that the tongue muscles could be used to **project the tongue** instead of pumping air. The **bolitoglossines** (a group of plethodontids) can project their tongue the length of their trunk and can hit moving targets. Their eyes are moved more forward, giving them stereoscopic vision and the nerves from each eye project to both hemispheres of the brain

as opposed to eyes more on the sides of the head and the nerves from each eye only projecting to the opposite hemisphere of the brain.

The social system of plethodontids has been studied by a number of investigators. Their small size and corresponding small home range makes behavioral studies relatively easier. Plethodontids have a **nasolabial groove** that runs from the external nares to the upper lip (figure 10-3). When it presses its snout on the substrate, it draws fluid into the nasolabial groove, which then passes into the nares and then to the **vomeronasal organ**, which is used for chemoreception (odors).

Males defend territories for feeding and mating purposes (figure 10-4). These territories are marked by **pheromones** and these marks are unique from one individual to another. Males are able distinguish the scent of a familiar male (his neighbor) from that of an unfamiliar male (an intruder). Males respond strongly and aggressively to the scent of intruders while ignoring the scent of neighboring males. This behavior of responding less to the scent of adjacent males has been called the "**dear enemy**" response.

Reproduction
Most use internal fertilization though some fully aquatic species do not. There is no intromittent organ and thus the sperm cannot be deposited directly into the reproductive tract of the female, rather the male deposits a packet of sperm (a spermatophore) and the female picks up the spermatophore into her cloaca (figure 10-11). For the transfer of sperm to take place, most species engage in a rather complicated courtship ritual, while in some the courtship is rather simple. During courtship a variety of secondary sexual characters (large tails, dorsal fans, coloration) are used as species recognition signals (figure 10-12). In addition, courtship involves the touching of the females by the males in order to deposit pheromones onto the skin of the female (figure 10-12). The female must also give positive feedback to the male for him to deposit the spermatophore. The female then walks over the spermatophore and picks it up into the cloaca.

If a species mates in the water, it will lay its eggs in the water. The young hatch as a gilled larval form that will eventually metamorphose into an adult. Paedomorphosis often occurs in which the larvae become sexually mature without metamorphosising into the adult form. This can vary from population to population within a species (***Ambystoma***).

The plethodontids, the most terrestrial of families, mates on land and some species lay their eggs on land. The larval stage occurs within the egg and the larvae metamorphose before they hatch. The newly hatched young look like miniature adults.

There are only four species (genus *Salamandra*) that give birth to live young. The eggs may be retained until hatching and get all of their nutrients from the yolk and the young are born as larvae. In one species, the alpine salamander, the embryos get nutrients from oviductal secretion and are born much larger and more fully developed.

Frogs and Toads (Anura, figures 9-5 and 9-6)

- 45 families with 5400 species (table 10-3), over 10 times as many species as salamanders
- specialized for jumping (figure 10-5)
- tibia and fibula fused into one solid bone, long hind legs and toes
- well developed, strong pelvic girdle, elongated ilium, development of a urostyle
- strongly braced, short vertebral column; **zygapophyses** restrict lateral movement of the vertebral column
- pectoral girdle designed to absorb shock when landing

In general, frogs have longer limbs and make long jumps (figures 10-6 and 10-7), while toads have shorter limbs and tend to make short jumps (hops). Some species, especially arboreal frogs, have longer limbs and move by walking and climbing using all four feet. Some of these have enlarged toe disks for clinging to vertical surfaces (figure 10-8). Because of the mechanism by which the toes can cling or not to a surface, a frog must orient with its head facing up for its toes to cling to a surface.

Calls

Frogs and toads are very vocal and much research has gone into studying these calls. Calls are species specific and serve as pre-mating isolating mechanism for many species. Mostly the calls are used for mating or territorial defense; these are **advertisement calls**. In most species, only the males call. Those species with **explosive breeding** (for example toads) will have most of the males in the population calling at once, while those species with **prolonged breeding** (for example bullfrogs) seasons the males establish territories to attract females over many weeks. Calling has a cost. Calling increases energy use by a frog and calling frogs that are out of the water tend to dehydrate much faster than non-calling frogs (box 10-1). The more males that are calling at one time, the more energy a male frogs puts into calling (figure 10-15) Calling also increases the rate of predation. Many predators are attracted to the calls of the frogs (for example, humans or bats).

Reproduction

In most anurans, fertilization is external (tailed frogs are the exception). Males and females engage in **amplexus**, in which the male is on the back of the female and he grasps the female with his forelegs. Amplexus is usually maintained for several hours but may be maintained for several days. In toads that have explosive breeding, the chaos of breeding often brings males in contact with males. To avoid male-male amplexus the males have a **release call** so that one male can recognize another male. Parental care and/or investment in the eggs and young varies greatly among the anurans (figure 10-18).

- Some species lay large numbers of small eggs and simply abandon them *(Lithobates* and *Anaxyrus*)
- Some deposit eggs in safer places, for example on branches overhanging the water. When the young hatch they fall into the water.
- Some lay large eggs (more nutrients) in pools in trees or at the base of bromeliads. *Dendrobates* returns to lay additional unfertilized eggs as food for the tadpoles.
- Some defend territories in which the eggs are laid.

- Some carry the eggs and/or tadpoles around with them on their backs (*Rhinoderma*, *Colostethus*, *Pipa*), in their mouths (*Rhinoderma*), or in their stomach (*Rheobatrachus*). Only five species give birth to live young (viviparity).

Larval Stage
Tadpoles are aquatic (figure 10-19). Generally, filter feeders or algae gleaners (figure 10-20). Algae gleaners have small keratinized beaks for scraping algae. Only a few are predaceous and these have much larger horny beaks for attacking their prey (often other tadpoles). Because of the difference in habitat between tadpoles and adults, these two life stages do not compete with each other for food. Thus the selective advantage of having a tadpole larval stage is this reduction in competition.

Eventually, the tadpole becomes inefficient at gathering food and will metamorphosis into an adult. This involves a complete reorganization of the body plan (table 10-5); development and growth of legs; loss of the tail; loss of gills and the development of lungs; and reorganization of the skull as modes of feeding change. The process is controlled by **thyroxine** from the thyroid, which is controlled by **thyroid stimulating hormone** (TSH) from the **pituitary**. The effect of thyroxine is very tissue specific and region specific. For example, muscle cells in the legs are stimulated to grow, while muscle cells in the tail are stimulated to atrophy.

Metamorphosis is generally divided into three stages
premetamorphosis is the growth phase **prometamorphosis** is when the hind legs appear
metamorphic climax is the period from when the front legs appear to when the tail disappears. This stage occurs very quickly as this is the stage when the animal is most vulnerable to predation.

Caecilians

- legless, burrowing or aquatic amphibians
- not many species and most are poorly known
- eyes are covered with skin or bone, but they are still sensitive to light
- a pair of tentacles between the eye and nostrils that are probably for chemoreception. In one species, the eye is attached to the tentacle and moves as the tentacle moves
- they are predaceous (as are all extant adult amphibians) on small invertebrates
- Fertilization is internal via an intromittent organ of the male. In some species, the females lay eggs (oviparous), but in most species the females give birth to live young (viviparous). Developing embryos eventually exhaust the yolk and get additional nutrients from the mother before birth. The fetuses bite or scrape the uterine wall, which cause a milky substance to be secreted. The fetuses eat this milk along with some tissue from the lining of the oviduct. Gas exchange is via the gills of the fetus being pressed up to the uterine wall.

Amphibian Skin

The skin of all amphibians is highly permeable to water and gases. To exchange gases the skin must be moist, but the skin also represents a potential area for extensive water loss, thus amphibians (especially anurans) have developed a number of physiological and behavioral adaptations to reduce water loss (figure 10-24). For example, the skin is covered with **mucus**

glands to aid in keeping the skin moist and in dehydrating conditions, an anuran will position its body to reduce the surface area that is exposed to the atmosphere. If an amphibian loses water, it can gain the water back once it is water. Many anurans have a **pelvic patch**, which is an area on the underside of the body that is highly vascularized for the uptake of water. An anuran can rehydrate by just having its belly in the water or on a wet substrate. Amphibians have several adaptation that allow them to survive periods of dehydration Amphibians have a lower **osmotic pressure** than other vertebrates. As they dehydrate, the osmotic pressure of the body fluid increases, but because it is so low to start with, the osmotic pressure can increase dramatically before it becomes life threatening. Anurans produce a very dilute urine, which is stored in the bladder. Unlike other vertebrates, anurans can get the water back. The bladder then serves as a canteen for an anuran out of water.

Defense in frogs and toads is often by poison, though this is also used by some salamanders (for example, the **parotid gland** on a toad or the skin glands in poison arrow frogs (Dendrobatidae)). Poison arrow frogs use **aposematic coloration** as a warning to predators. A wide variety of compounds have been isolated from the skin and/or mucus of frogs and toads. These compounds have a variety of effects on predators that range from being noxious to lethal. Predators that have been captured where these animals naturally occur avoid attacking these animals, while naive predators quickly learn to avoid these animals.

Last updated on 12 March 2012
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