

Lecture 13

Frogs

- Small terrestrial Central American Frog
- Breed in small pools
- Breeding assemblies range from a single male to choruses of several hundred males
- Produces an advertisement call of a whine, or a whine followed by one or more
 - If the male is alone, it usually only produces a _____
 - As additional males join the chorus, more of them produce calls that include chucks
 - Why?
 - Females are attracted to the more _____ call
 - Why not use chucks all the time?
 - Energy expenditure?
 - Measurements suggest that energy cost is not related to number of _____
 - Predation?
 - Frog-eating bats locate frogs by homing in on _____
 - Bats fly towards whine-chuck calls more frequently than whines
 - The risk of predation for an individual frog decreases with the size of the chorus – at the same time, _____ for females increases

Modes of Anuran Reproduction

- Fertilization is usually external
 - _____ occurs
 - Male uses _____ to claps the female
 - May be maintained for _____
- Rarely, fertilization is _____
 - Tailed frog has extension of the _____ that is used to introduce sperm into the cloaca of the female
 - Frogs that lay eggs on land and frogs that give birth to live young *probably* have internal fertilization
- Large eggs produce large offspring that have a _____ chance of surviving than smaller ones
 - Large eggs also require more _____ to hatch and are exposed to _____ for a longer time

- Evolution of large eggs and hatchlings is often accompanied by the evolution of _____ that protect the eggs and sometimes the tadpoles
 - Arboreal frogs lay eggs in leaves of trees overhanging water
 - Eggs develop away from _____ and drop into the water as tadpoles
 - Frogs such as *Physalaemus pustulosus* constructs foam nests that float on the water surface
 - _____ nest is created by mucus secretion from the female that is beaten into a foam by the hind legs
 - Tadpoles drop through the foam into the water after hatching
 - Some frogs lay eggs in water that accumulates in _____ (tropical plants that collect rainwater)
 - Some frogs lay eggs on land near _____
 - Eggs or tadpoles are released from the nest when pond levels rise after a rainstorm
 - Some frogs construct pools in the mudbanks beside streams
 - Structures are filled with water by _____ or seepage
 - Some frogs lay large eggs on land that develop directly into little frogs

Parental Care

- Adults of many species of frogs guard the eggs
 - Some frogs that lay eggs over water remain with them
 - Many terrestrial frogs that lay direct-developing eggs remain with the eggs and will _____ an animal that approaches the nest
 - Male African bullfrogs guard their eggs and tadpoles
 - Males move with the young tadpoles and may dig channels that allow young to move from one pool in a marsh to another
 - Some poison-dart frogs deposit eggs on the ground and transport tadpoles to water
 - Tadpoles adhere to the surface of the _____
 - Panamanian frog carries tadpoles for more than a week, and the tadpoles increase in size
 - Tadpoles apparently feed while being transported by the mother
 - At least one poison-dart frog releases tadpoles into pools of water and deposits _____ for the young to eat
 - Some frogs carry eggs with them
 - European midwife toad

- Male gathers the egg strings around his _____ as the female lays them
- He carries them until they are ready to hatch and then releases them into the water
- Darwin's frog
 - Male carries eggs in _____ which extend back to the pelvic region
 - Young emerge as fully developed froglets
- Some female tree frogs carry eggs while they develop into froglets
 - Open oval depression
 - Closed pouch
 - Individual pockets
- Surinam toad
 - Skin of female's _____ thickens and softens
 - During amplexus, frogs swim in vertical loops, and eggs fall on female's back, where they are pressed in by the male
 - Eggs develop through metamorphosis in _____ on the back
- Swallowing eggs
 - Rheobatrachus silas-
 - Retains eggs or newly hatched larvae in _____ through metamorphosis
 - Modifications-
 - _____ of proximal portion of stomach
 - Separation of individual muscle cells from surrounding connective tissue
 - _____ of hydrochloric acid secretion
 - Rheobatrachus vitellinus
 - Retains eggs in stomach
 - Lacks extensive structural changes in stomach
- Viviparity
 - Only a few species give birth to live young
 - A few species have embryos that feed on secretions from the walls of the oviduct
 - A few have embryos that acquire nutrients only from the _____ of the egg

Ecology of Tadpoles

- Body form
 - Tadpoles that live in still water have _____ bodies and tails with fins that are as large as the muscular part of the tail

- Tadpoles that live in fast-moving water are more _____ and have smaller tails
- Semiterrestrial tadpoles are often dorsoventrally _____ and have little or no tail fin
- Mouth size
 - Direct-developing tadpoles have reduced mouthparts (and large yolk supplies)
 - Filter-feeding tadpoles that hover midwater lack _____ mouth parts
 - Species that graze from surfaces have small _____ that are often surrounded by rows of denticles
 - Predatory tadpoles have larger beaks that can bite pieces from other _____
 - Some surface-feeding tadpoles have greatly expanded mouth-parts (funnel mouths) that skim material from the surface of the water
- Benefit of Tadpole Stage
 - Tadpoles can exploit _____ that are not available to adult anurans
 - Many aquatic habitats experience annual flushes of primary production, when nutrients are washed into a pool by rain and melting snow stimulating rapid growth of _____
- Food Acquisition
 - All tadpoles extract suspended food _____ from the water
 - Feeding and _____ of gills are related activities
 - Stream of water moves through the mouth and nares to ventilate the gill and carry particles of food
 - Small particles of food are trapped in _____ secreted by epithelial cells in the branchial basket
 - Mucus is transported from gill filters to grooves on the roof of the _____ to the esophagus
 - Some bottom-feeding tadpoles _____ to create currents that lift food particles into suspension
 - As tadpoles grow bigger, they become less effective at gathering food because of the changing relationship between the size of food-gathering structures and _____
- Predator Avoidance
 - Tadpoles of African Clawed Frog are nearly _____
 - Some midwater tadpoles form _____ which may confuse predators

Metamorphosis

- 3 periods of anuran larval development
 - _____
 - Tadpoles increase in size with little change in form
 - _____
 - Hind legs appear and growth of the body continues at a slower rate
 - Metamorphic _____
 - Forelegs emerge and tail regresses
 - Most _____ stage
 - Most _____ stage
 - Long tail prevents effective jumping
 - Legs prevent fast swimming
- Changes are stimulated by actions of _____
 - Effect of thyroxine in a given tissue is genetically determined
 - Virtually every tissue of the body is involved
 - When administered to striated muscles of the leg, it stimulates _____
 - When administered to striated muscles of the tail, it stimulates _____ of tissue

Exchange of water and gases

- Glandular skin that lacks external _____
- Highly permeable to gases and water
- _____ glands keep skin moist and permeable
 - Dry skin reduce permeability
 - Dry skin reduces oxygen uptake
 - Dry skin reduces evaporative _____
 - Interference with gland secretion can lead to overheating
- Amphibians depend on cutaneous respiration for a significant part of their _____ exchange
- _____ is actively transported from the outer surface to the inner
- Urea is retained by skin

Blood flow in Larvae and Adults

- As lungs develop, they are increasingly used for _____
- As the gills lose their respiratory function, the _____ arches change their roles
 - Arches 1 and 2 are lost early in embryonic development
 - Arches 3-5 supply blood to the gills and arch 6 carries blood to the dorsal aorta via a connection called the ductus arteriosus

- At metamorphosis, arch 3 becomes the supply vessel for the internal _____ arteries
 - Initially arches 4 and 5 supply blood to the dorsal aorta, but arch 5 is usually lost in anurans, so arch 4 becomes the main route by which blood from the heart enters the aorta
 - Arch 6 primarily supplies blood to the _____ and skin via the pulmocutaneous arteries
- Atrium of the heart is divided into left and right chambers
 - Blood from systemic veins flows into the right side of the heart
 - Blood from the lungs flows into the left side
 - A spongy muscular _____ of the ventricle minimizes mixing of right side and left side blood
 - Oxygen-poor blood enters the right atrium and goes to the pulmocutaneous arch, toward the lungs
 - Oxygen rich blood from lungs goes to left atrium and from there to the head and body
 - What if the frog is underwater and oxygen in the lungs is minimal?
 - Vascular _____ prevents blood from passing through the pulmonary circuit
 - The majority of the blood arrives from the systemic circuit
 - The skin is the primary site of gaseous exchange
 - Most oxygenated blood from the heart flows to the tissues of the head and body

Water conservation

- Anurans and salamanders in deserts may spend _____ months of the year in moist retreat sites
- Many arboreal frogs have skins that are less permeable than that of terrestrial frogs
- Some spread _____-containing secretions of dermal glands over the body surface with their legs
- Some excrete nitrogenous wastes as _____ of uric acid rather than as urea
- Activities of many frogs (like the Puerto Rican Coqui) vary depending on rainfall
 - On nights after a rainstorm
 - Vocalize soon after dusk and until midnight
 - When calling, they _____ off the surface of the leaf
 - On dry nights
 - Call only sporadically
 - Keep in water-conserving position with body and chin _____ against the leaf surface and legs pressed against the body to reduce surface area for evaporation

Uptake and storage of water

- Amphibians do not drink water
- Species that live in aquatic environments have a constant osmotic influx of water
- Terrestrial species utilize a _____ patch
 - Pelvic patch is an area of highly vascularized skin in the pelvic region
 - Responsible for a large portion of an anuran's cutaneous _____ absorption
 - Allows absorption from a thin layer of moisture on a rock or from wet soil
- Urinary bladder plays an important role
 - Kidneys produce urine that is _____ to the blood
 - Urine in the bladder is dilute
 - Amphibians can reabsorb water from _____ to replace water lost by evaporation
- Behavior plays a role (leopard frog example)
 - Spend days in retreats absorbing water from soil
 - On dewy nights, sit on dew covered grass to absorb moisture
 - In morning they're moist and have urine
 - In evening they're skin is dry and have little urine in bladder

Defense Mechanisms

- For some amphibians, mucus makes the body _____ and hard for predators to hold
- For some amphibians, mucus is extremely _____.
 - Sticky mucus causes debris to adhere to the predator's mouth, which may distract the predator to clean itself rather than continue the attack
 - If the predator is a snake, sticky mucus may make a salamander difficult to swallow and may even cause the snake to become _____ to itself
- Primary chemical defense system is located in the poison glands
 - Concentrated on _____ surfaces of the animal
 - Defense postures present these glandular areas to potential predators
 - Frogs obtain toxic alkaloids from the prey that they eat, and the more varied their diet, the greater the number of compounds present
 - Many advertise distasteful properties with aposematic coloration
 - Some have _____ coloration and reveal _____ coloration on ventral surface when attacked
 - Several salamanders have ribs that pierce the body wall when a predator seizes the salamander
 - Predator's _____ is poked by spikes
 - Ribs penetrate poison glands introducing poison into the wound
 - Many anurans escape predation by making large leaps through the air
 - Some anurans feign _____, lying with outstretched limbs
 - Posture may also make them blend into the background of leaves

- Large anurans _____ predators
 - Increase size by inflating with air
 - Often croak loudly
- At least one frog emits a foul, skunk-like _____ when handled

Mimicry

- Unpalatable animals that deter predators with aposematic color create an opportunity for palatable species to escape predation as well
- A _____, which resembles a noxious species in appearance, may be avoided by a predator that has encountered a noxious individual and has learned to avoid it

Why are Amphibians Vanishing?

- Global decline of amphibians is alarming because we don't know why species are disappearing
- Local Events
 - _____ changes the local environment
 - Sunlight reaches the ground and conditions become too hot and dry
 - _____
 - Rock removed from mines releases acid or toxic chemical
 - Cyanide used to extract gold from ore poisons surface water
 - Extraction of oil
 - Oil wells spread toxic hydrocarbons
 - _____
 - Nitrates and nitrites drain from farmland and reach levels that cause deformities and death of amphibian larvae
 - Grazing cattle leave deep hoof prints that can become death traps for newly metamorphosed frogs and toads
- Declines without local environmental damage
 - Increased _____ precipitation
 - Extra acidity is produced by nitric and sulfuric acids from combustion of fossil fuels
 - Embryos of many species are killed or damaged at a pH of 5 or less
 - Larvae that hatch may be smaller than normal, and sometimes have strange lumps or kinks in their bodies
 - Sometimes these animals have trouble capturing prey
 - Increased _____ radiation
 - The amount of UV radiation is increasing as a result of destruction of the ozone in the stratosphere by chemical pollutants
 - UV light kills amphibians and embryos
 - Disease
 - _____ fungi may be a new pathogen for amphibians

- Chytrid infections do not appear to be lethal to tadpoles, but adults don't survive
- Frogs collected 20 years ago show no signs of chytrids, suggesting the fungus may have been introduced recently
- Interactions
 - Amphibians that are _____ by acidity or ultraviolet radiation may be susceptible to diseases or parasites that they would ordinarily be able to resist