Larval Amphibian Ecology

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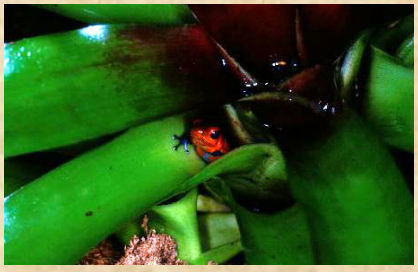
Amphibian Larvae

- Have hatched
- Are morphologically distinct
- Are non-reproductive
- Passes through metamorphosis
- Usually are aquatic and feeding (with exceptions)

Direct developing
Eleutherodactylus eggs



Phytotelm breeders:
e.g., *Dendrobates pumilio*

Salamanders

- Morphology: conserved
- Elongated, salamander-like appearance from early on in development
- External gills, tail fin, large heads, no eyelids
- Skeleton contains bone, teeth in jaws

Ambystoma maculatum

Salamanders: Larval types

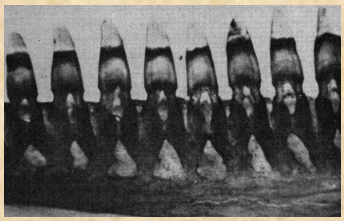
- Larviform
- Body shape varies with habitat
- Terrestrial
- Pond type
- Stream type
- Mountain-brook type

Stream type

Pond type

Salamanders: Metamorphosis

- More gradual than in anurans
- Tail fin reduces (resorbed)
- Skin becomes thicker
- Gills resorbed, gill slits close
- Lungs develop
- Palate restructuring
- Teeth become pedicellate



Pedicellate teeth

Salamanders

- Larviform (i.e. neotenic or paedomorphic):
- Adults that look like larvae (failure to metamorphose completely)
- Some obligate, others facultative

Larval salamander ecology

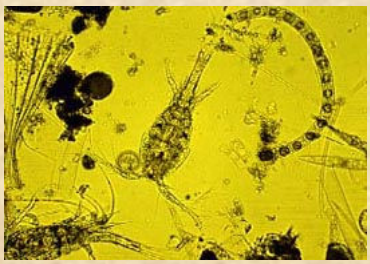
Developmental modes:

- Eggs laid: aquatic eggs, aquatic larvae (most spp.)
- Non aquatic eggs and aquatic larvae
- Non aquatic eggs and direct development (e.g., *Plethodon, Ensatina, Aneides* + *Bolitoglossini*)
- Viviparity (e.g., salamandrids)

Plethodon vandykei

Salamanders: Diets

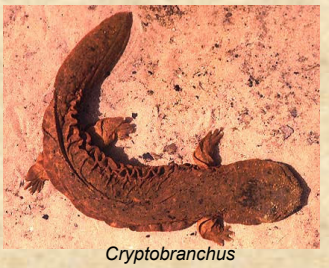
- Almost all are carnivorous
- Suction feeding
- Pond dwellers: small prey (e.g., zooplankton)
- Stream dwellers: larger prey
- Cannibalism is common



Zooplankton

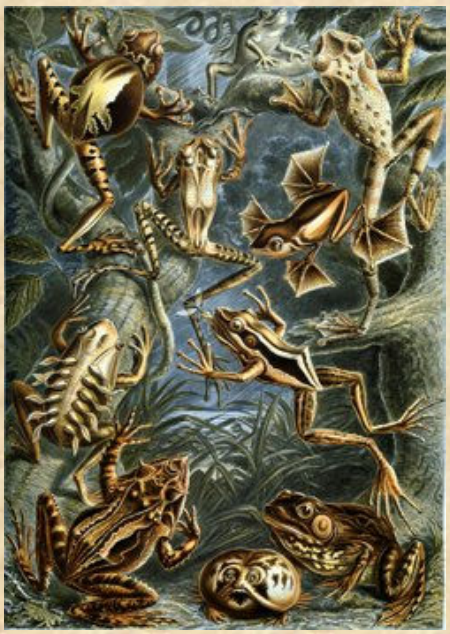
Salamanders

- Larval period: varies between 40 days (e.g., *Hemidactylium scutatum*) to 5 years (*Cryptobranchus alleganiensis* and *Necturus maculosus*).
- Development time dependent on food availability and water temp.



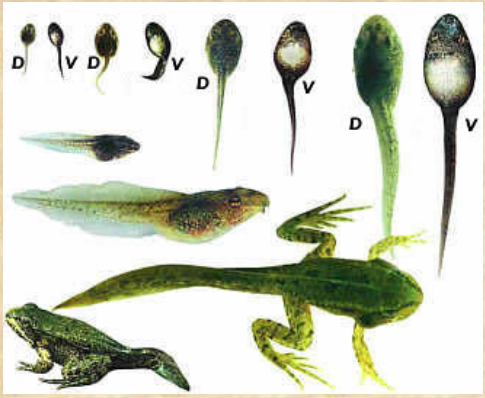
Cryptobranchus alleganiensis

Frogs



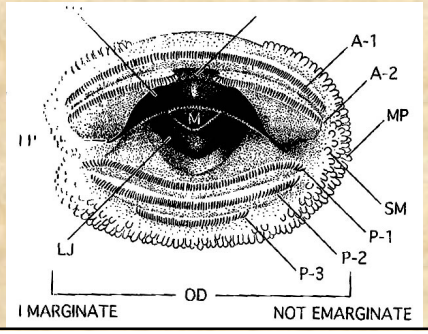
Frogs: Tadpole Morphology

- Limbs appear relatively late as larvae
- Gills quickly covered with operculum (front legs develop behind operculum first)



Frogs: Tadpole Morphology

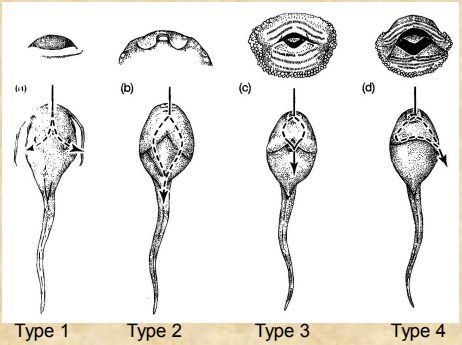
- Oral disc (jaw sheaths, labial teeth, lobes and papillae)
- Keratinized mouthparts (jaw sheaths and labial teeth)
- Variable number of tooth rows & papillae



Frogs: Tadpole Types

Grace Orton

- Type 1: Pipidae + Rhynophrynidae
- Type 2: Microhylidae
- Type 3: *Ascaphus, Leiopelma*, Bombinatoridae, + Discoglossidae
- Type 4: all other frogs

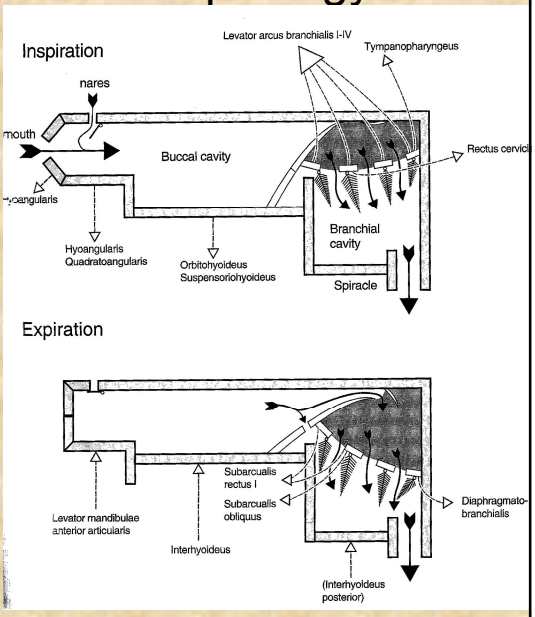


Frogs: Internal Morphology

- Path of digestion:
  Branchial basket>esophagus>manicotto glandulare (secretes HCl, enzymes)
- Mid and hindguts (elongated)
- Nitrogenous wastes excreted by kidneys as ammonia
- Reproductive organs begin to differentiate midway through development
- Cutaneous respiration primary

Frogs: Functional Morphology

- Feeding and respiratory systems:
- Water taken in through mouth
- Passes across gills
- Exits through spiracle



Tadpole Habitats and microhabitats

- Benthic, midwater, surface feeders
- Burrow in substrate of streams
- Suctorial mouthparts, belly suckers

Amolops sp.

Tadpole Habitats and microhabitats

Some primarily predator (e.g., fish) free

- Phytotelms
- Tree holes, bamboo stalks
- Seed husks

Selected based on abiotic factors:

- Dissolved O_2
- Water depth, flow rate
- Substrate texture and quality
- Ephemerality
- Temperature

Tadpole Feeding

Filter feeding
Carnivorous (e.g., *Hymenochirus*, *Ceratophrys*)
Cannibalistic (e.g., *Rhinophrynus*)
Cannibalistic "morphs" in *Scaphiopus* and *Spea*
Mutualist nematodes in hindguts of *Rana catesbeiana*

Rhinophrynus dorsalis


Rhinophrynus dorsalis tadpole


Scaphiopus multiplicatus

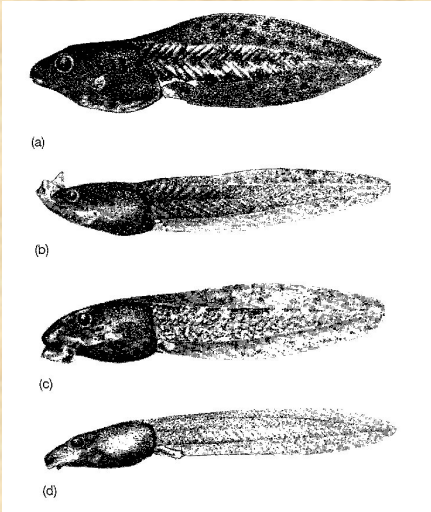
Frog life cycle

- As little as 8 days (*Scaphiopus couchii*)
- As long as 2–3 years (some high altitude *Rana,* leptodactylids) or up to 5 years (*Ascaphus*)
- Determining factors (other than phylogeny): food availability, temperatures, density of conspecifics, competitors, predators
- High density retards development because of proteinaceous compound

Scaphiopus couchii

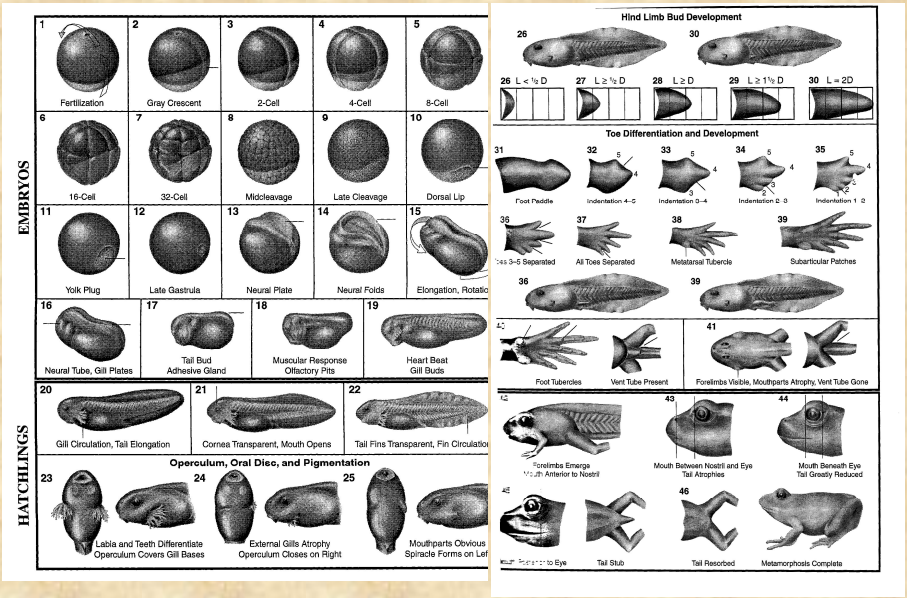
Ecomorphology

Tremendous adaptive radiation
Body shape etc., determined by:
1) Source of energy
2) Type of aquatic environment
3) Feeding biology



Rana palmipes (slow waters)
Megophrys montana (slow waters)
Hyla rivularis (stream dweller)
Hyla bromeliacia (bromeliad dwelling)

Staging larvae: Gosner stages

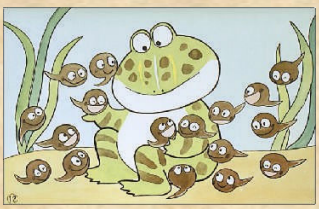


Frogs: Metamorphosis

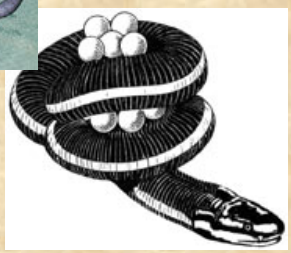
- Metamorphosis: relatively abrupt

Drastic morphological changes:

- Digestive gut shortens; stomach forms
- Tadpole mouthparts disappear; replaced by teeth, etc.
- Movable eyelids
- Lungs form
- Cartilaginous skeleton replaced with bone
- Tail resorbed
- Limbs form



The Great Caecilian Mystery...



Caecilians

- Very poorly known
- Most (70%) are oviparous; mostly with aquatic larvae
- Direct development occurs in Caeciliidae
- Viviparity occurs in African and S. American species of Caeciliidae, all Typhlonectidae, and *Scolecomorphus*

Boulengerula taitanus

Caecilian larvae

- Hatched at relatively advanced stage
- Lungs well developed
- Larvae lack tentacles
- Lateral line developed
- Ampullary (electroreceptive) organs prominent on head

Ichthyophis embryo

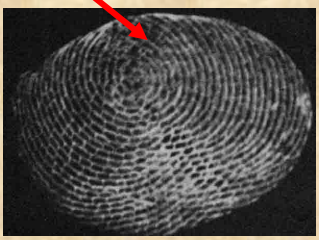
Caecilian larval ecology

- Mostly unknown
- *Ichthyophis* and *Epicrinops*: found in mud or under objects at water's edge; larval development up to a year
- Likely nocturnal
- Subterranean during day, forage at surface at night?

WHO KNOWS??

Caecilians: Metamorphosis

- Relatively gradual
- External gills lost within days of hatching
- Lateral line, tail fins lost at metamorphosis
- Scaled species gain scales
- Color change



Frogs, salamanders, and caecilians compared

Caecilians and salamanders:

- General morphological resemblance to adult
- Metamorphosis is gradual
- Predaceous, functional teeth and jaws

Anurans:

- Larvae dramatically different from adults
- Lack true teeth, long digestive tract
- Metamorphosis is dramatic

Behavior and Physiology of Larval Amphibians

Abiotic factors:

- Light (mostly averse to light=negatively phototaxic)
- O_2 content:
- Temperature
- Salt tolerance

Lentic

Lotic

Phytotelm

Behavior and Physiology of Larval Amphibians

Parental care:

- Egg attendance
- Feeding unfertilized eggs to offspring

Dendrobates pumilio

Osteocephalus oophagus

Anotheca spinosa

Behavior and Physiology of Larval Amphibians

Parental care:

- Carrying tadpoles
- Nest chamber (e.g., *Plethodontohyla inguinalis*)
- Transporting tadpoles to more favorable environment

Alytes obstetricans

Hemiphractus johnsoni

Colostethus subpunctatus

Gastrotheca cornuta

Behavior and Physiology of Larval Amphibians

- Social interactions
- Aggregations in response to abiotic factors
- Predator avoidance
- Thermoregulation (e.g., *Bufo* tads)
- Schooling polarized or not

Dragon fly larva vs. frog larva

Bufo tadpole school

Metamorphosis

- Under hormonal control
- Growth regulated by prolactin (pituitary gland), thyroid stimulating hormone (pituitary gland), corticotrophin releasing hormone (hypothalamus)
- **Obligate** = metamorphosis always takes place
- **Facultative**= may or may not occur

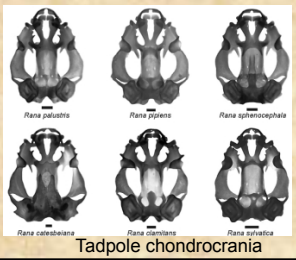
Metamorphosis: Biochemical change

- Hormones
- Blood: hemoglobin with higher O_2 affinity
- Liver: Ammonotelism > ureotelism
- Skin: Osmoregulation improves
- Eye: eye pigments change

Hyla chrysoscelis
metamorph

Metamorphosis: Morphological change

- **Skeleton**: e.g., development of limbs; increased ossification
- **Skin**: becomes thicker
- **Musculature**: e.g., degeneration of tail
- **Digestive system**: In frogs, drastic; metamorphs nonfeeding
- **Urogenital system**: pronephric kidney> to adult (varies)
- **Sensory systems**: Lateral lines degenerate; tentacle (caec.) develops



Tadpole chondrocrania

Metamorphosis

- Plasticity
- Rate of metamorphosis modulated by environmental cues

E.g.,: drying pond will increase hormones which stimulate growth

Downside: often metamorphose at smaller size

Larval husbandry

- Little known about many taxa
- All husbandry information gathered on various taxa should be recorded and made available.

Larval husbandry

Caecilians (Viviparous spp.)

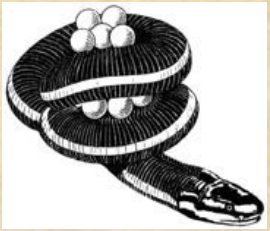
- Viviparous, miniature adults
- Some evidence that viviparous offspring may be better kept with parents
- Lower water depth for gravid mothers

Typhlonectes natans

Larval husbandry

Caecilians (Oviparous spp.)

- Some direct developing (larvae treated as viviparous spp.)
- Egg clutches found in moist ground, never in water
- Larvae amphibious
- Carnivorous
- Maternal attendance (why?)



Larval husbandry

Caudates

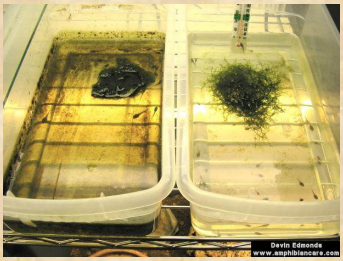
- All carnivorous, some cannibalistic
- Maintain in low densities to limit intraspecific competition
- Will feed on animal-based foods (e.g., small worms, daphnia, brine shrimp, chopped fish, mosquito larvae, etc.)

Ambystoma maculatum larvae

Larval husbandry

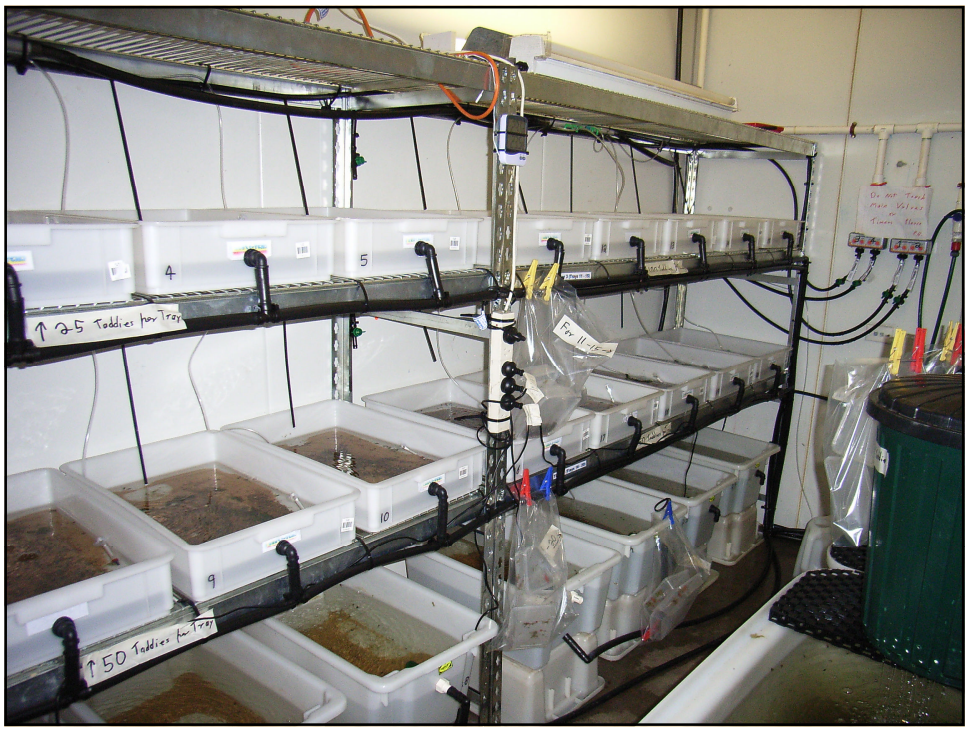
Anurans

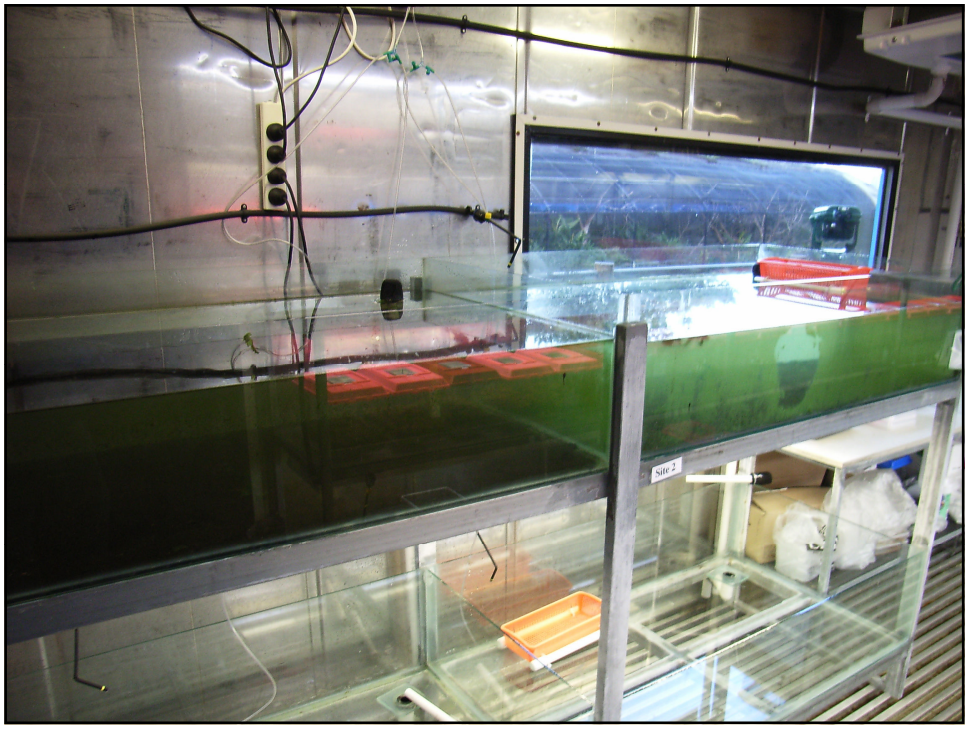
- Much more to consider re. diversity
- Most tadpoles are herbivorous or omnivorous
- Potential foods: commercial fish flakes, tabs, Sera Micron (filter feeders), “Zippy flakes”
- Vary foods as much as possible
- **Water quality!**



Stocking Density

- The stocking density of tadpoles will largely depend on the water quality and the amount of water flowing through.
- Increased density may cause:
  - Increased competition
  - Decreased water quality
  - Smaller metamorph size
  - Longer larval period
  - Lower survivorship


↑ 25 Toddies per Tray
4
5
9
10
↑ 50 Toddies per Tray



Water Quality

- Water should be tested frequently to determine the quality of the water.
- Appropriate filtration or water changes should be carried out to maintain quality.
- This will largely depend on the stocking density and the quality of source water.

Feeding

- Largely dependant on the species.
- The diet should be varied if possible.
  - Commercial foods, including Sera micron, algal flakes, spirulina flakes, various fish flakes.
  - Frozen endive or lettuce.
  - Naturally growing algae.
  - For omnivorous species, bloodworm and shrimp may also be added.

Water Temperature

- Attempt to replicate the temperature in the natural habitat of the species being raised.
- As a general rule:

  ↑ temp = ↓ larval period, ↓ metamorph size

  ↓ temp = ↑ larval period, ↑ metamorph size

As metamorphosis approaches….

- Ensure that the tadpoles have a land area so that they can climb out of the water and not drown.
- It is equally important to make sure that the enclosure is escape-proof for the young frogs.