

Amphibian Courtship and Mating



Matthew J. Gray, Ph.D.
College of Agricultural Sciences and
Natural Resources
University of Tennessee-Knoxville



Goal of the Lecture

To familiarize students with amphibian courtship and mating strategies, including the mechanics and costs of reproduction.

Reading Assignments:

- 1) Handout: reproductive energetics
- 2) Duellman and Trueb: Chapter 3
- 3) Types of Calls: mp3 file on website

Lecture Structure

- I. Breeding Site Cues
- II. Anuran Vocalization
- III. Secondary Sexual Characters
- IV. Courtship
- V. External vs. Internal Fertilization
- VI. Comparative Costs of Reproduction

Finding a Mate


Cues Used to Find Conspecifics

Two cues are needed to orienteer (Sinsch 1990)

Maximum dispersal of most species is <3 km

1) Auditory Cues

- Used Exclusively by Anurans
- 10-100 m: Most Anurans
- 500-1000 m: Bufonids, Spadefoots



2) Olfactory Cues

- Breeding Site Odors (algal blooms)
- Blinded and Olfactory Ablation Studies
- Green Frogs: 550 m
- Newts: 3-4 km

Remove olfactory nerve

3) Visual Cues

- Celestial Bodies (circadian clock)
 - Diurnal: sun or skylight
 - Nocturnal: stars and moon
- Fixed Visual Landmarks (forest edge)
 - Blindfolded: Less Direct Route

4) Magnetic Cues

- Magneto-Perception (compass system)
- Masking Earth's Magnetic Field
- Anurans: Migratory Experience
- Newts: Displaced 8 km; return to natal stream

Importance


- Short-distance (<500m): #1 and #5
- Long-distance (>500m): #2, #3, and #4

Vocalizations

Salamanders and Caecilians

- Some Plethodontids, Sirens, and Amphiumas
- Family Caeciliidae (few)
- Barks, Squeaks, Whistles

➔
Predatory Defense



Anurans

- All Anurans: except Tailed Frogs (Ascaphidae) and Leiopelmatids
- Call: entire assemblage of acoustic signals in a sequence
- Note: single pulse (bird-voiced treefrog) or series of pulses (trill: gray treefrog)
- Loudness: measured in decibels (dB)
- Pitch: measured in frequency (Hz)


Transmission:

- Anurans: <5000 Hz
- Humans: 800-2500 Hz

Lower Frequencies Travel Farther

Body Size

- >Large: Lower Freq, Higher Pulse Rates, Longer Duration
- >Small: Higher Freq, Lower Pulse Rates, Shorter Duration



100 dB

Mechanics of the Typical Anuran Call


Pipidae Exception
 Rapid Contraction of Laryngeal Muscles

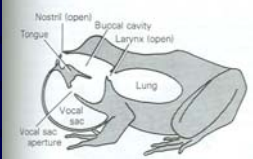
1) Inhale Lungs

2) Close Nares

3) Contract Trunk Muscles

- Oblique Muscles





Labels: Nostril (open), Tongue, Buccal cavity, Larynx (open), Lung, Vocal sac, Vocal sac aperture

5) Buccal Cavity

6) Vocal Slits

7) Vocal Sac

- Resonates Sound

8) Nares Open

4) Larynx (vocal cords)

- Muscular energy ➔ acoustic energy

•Single notes: inhale every time
 •Multiple Pulses: resonate & trunk muscles may periodically contract

Sound Power

- 100-115 dB @ 0.5 m
- 90 dB : Songbirds

No correlation between body size and dB

Types of Vocal Sacs

1) Median Subgular


- Single Sac in Throat
- Most Common



2) Paired Subgular


- Two Sacs in Throat
- Partially or Completely Separated

Pternohyala fodiens



3) Paired Lateral


- Behind & Below Jaw



Internal

- Skin not modified
- Call from water (buoyancy)
- Usually lower frequency


#2 and #3



External

- Skin modified: Thin and Folded

#1 and #2



Types of Anuran Calls

1) Advertisement Call

A) Courtship Call

Male vocalization used to attract female conspecifics for mating

B) Territorial Call


Male vocalization produced in response to an advertisement call from another male

- Most common in tropical frogs

C) Encounter Call

Male vocalization produced in response to a close encounter with another male

- Often: Quick Trill





G. Krupa

Hybrid Calls
Both Characteristics

- H. cinerea x H. gratiosa
- Genetic Basis!!

D) Compound Advertisement

Combines both A and B




Eleutherodactylus coqui

“Co”: B
“qui”: A

Types of Anuran Calls

2) Reciprocation Call Discoglossidae, Pelodytidae

Female vocalization (some species) in response to a male advertisement call or amplexus



3) Release Call

Acoustic signal (corporal vibrations) in response to an un-welcomed amplexus


- Stimulate by gently applying pressure with thumb and forefingers to axillary region




4) Distress Call

Loud vocalization (often a squeak) in response to a disturbance or capture by a predator

- Mouth Open



Advertisement Call Strategies

- 1) Simultaneous vs. Synchronous Callers**
 - Simultaneous: Explosive Breeders (BS <2 weeks)
 - Synchronous: Prolonged Breeders (BS >1 month)
 - Males alternate calls to minimize overlap
- 2) Change in Call Rate**
 - Increase call rate when female is detected
 - 10-20 sec call once per minute
 - 5 second interval between calls
 - Increase # of pulses
- 3) Long Calls and Fast Rates**
 - Females prefer **longer** calls @ faster rates
 - Often correlated with body size

Long, Slow
over
Fast, Short
- 5) Satellite Males**
 - Smaller Males
 - Intercept Females
- 4) Chorus Leaders**
 - Females attracted to speaker that initiated chorus
 - No** evidence of dominance hierarchy

Factors Influencing Advertisement Calls


- 1) Temperature**
 - Linear relation with call and pulse rates
 - Relation decouples toward end of BS (ε)

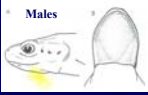

•Temperature Coupling
Females are attracted to calls produced at temperatures similar to their body temp
- 2) Vegetation**
 - Grasslands: 500-1000 m
 - Longer, continuous calls @ lower freq
 - Forests: <100 m
 - Shorter calls @ higher frequency
- 3) Soil**
 - Lower frequency (<1000 Hz, opercular)
- 4) Rivers**
 - Short calls @ higher frequency
 - Streams: 1275-4300 Hz (2530)
 - Forest Ponds: 272-3578 Hz (1726)
 - Centrolenids and Dendrobatids
 - Some don't call (e.g., Ascaphus)
- 5) Food Resources (Grafe 1996)**
 - Call rates of unfed males are lower
 - Unfed males 2X lipids as fed males
 - Unfed males sustain 15 nights of calling on stored lipids alone

Secondary Sexual Characteristics

Caecilians: The anal region of males forms a circular depression.
➢Suction or clasping mechanism when the phalloseum is inserted.

Salamanders:

- 1) Sexual Dimorphism:**
 - Females larger in some families (e.g., Ambystomatids)
- 2) Enlarged Cloaca:** ➢Males appear swollen (enlarged cloacal glands)
- 3) Caudal and Dorsal Fin:**
 - Aquatic Salamanders
 - Salamandridae
 - Ambystomatidae
 - Males larger

Triturus vulgaris
- 4) Head Glands:**

- 5) Nuptial Excrecences:**
 - Keratinized Epidermis
- 6) Nasolabial Grooves & Premaxillary Teeth:**
 - Male Plethodontids
 - ➔ Elongated & Monocuspid (some)


Secondary Sexual Characteristics Anurans

1) Sexual Dimorphism:


- > Females larger (most)
- > Converge: Aggressive Species

4) Nuptial Excrecences:

- Keratinized Epidermis
- Stimulate ovulation

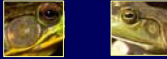


2) Vocal Sac: (external spp)




5) Tympanum:

- Most Anurans: same size or larger in female
- Ranids: male larger (esp. *R. catesbeiana* & *clamitans*)




3) Eggs:

Species with clear ventral skin



6) Others:

- Glands (several families)
- Elongated 3rd finger (*Colostethus*)
- Tusks or spines (some families)
- Hair-like projections (*Trichobatrachus robustus*)



Amphibian Courtship

Caecilians: •Very little known

Salamanders: •Hynobiids, cryptobranchids, and sirens (likely): none → External Fertilization


•All others: elaborate → Internal Fertilization

General Steps:

- 1) Male detects female, approaches and nudges with snout
- 2) Male blocks path and continues nudging or tail movements
- 3) Male moves away from female (she follows if enticed)
- 4) Male deposits spermatophore
- 5) Female picks up spermatophore with lips of cloaca

Energetic Costs:

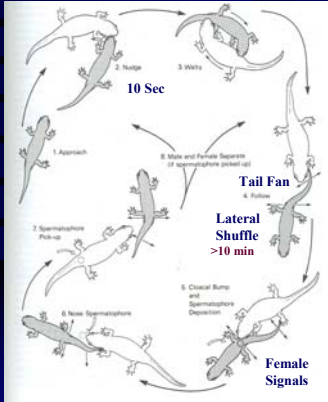
- Terrestrial
- 1 hour
- 38% C > resting
- 75% F > resting



• Aquatic
→ 2 hrs (often)
→ 1 courtship seq. (often)
• Water quality can affect courtship bouts
• E limited (likely)!

Olfactory and visual cues

Amphibian Courtship Salamanders: Family Ambystomatidae




10 Sec



Tail Fan
• Pattern

Lateral Shuffle
• >10 min

Female Signals



- Males arrive first
- Early Breeders (except xeric) (January-March, Summer)
- Deposit on Submersed Structure (usually vegetation)


- Predators
- Paedomorphic

Anuran Courtship

In general, NOT elaborate!


1) Advertisement Calls

- Primary Courtship Cue
- Male Generally Calls until Nudged



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- Female positions for amplexus
- Preamplexic rituals exist
 - Some frogs (sub-tropical/tropical)






2) Conspecific Recognition

Tactile Cues

- Size: *B. americanus* vs. *B. woodhousii*
- Former: females smaller
- G. carolinensis* vs. *G. olivaceus*
- Former: females larger

•Skin Texture


Explosive Breeders & Satellite Males


"No release call!"

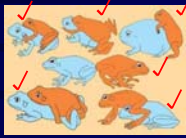
Types of Amplexus

Anurans





Vents not Juxtaposed






Duration:
1-2 hrs






Inguinal



Cephalic



Axillary

Others: glued (*Breviceps*), straddle (*Mantidactylus*), independent (*Dendrobates granuliferus*)

External Fertilization

Salamanders:

Asian Salamanders, Hellbenders, and Sirens

- Very similar to fish
- Female deposits eggs, male moves over eggs and deposits sperm
- Pair of Egg Sacs or String



Anurans:

Clutch >100 Aquatic Oviposition

- Abdominal contractions signal male
- Female arches ventrally, male dorsally
- Male releases sperm as eggs are deposited
- Male may use hind feet to organize eggs
- Female *Bufo* frequently walk in water leaving eggs in 2 strings




Clutch <50 Arboreal Oviposition

- Oviposition often occurs on a leaf
- Abdominal contractions signal male
- Male arches dorsally: continuous contact
- Male releases sperm as eggs are deposited
- Pair moves forward as eggs are deposited

•Eggs are usually hydrated & defended

•Various development strategies



Internal Fertilization

Caecilians:



- Phallosome: intromittent organ made of connective tissue from the cloaca that is used to deliver sperm
- Sperm delivered down longitudinal tracts
- Copulation occurs for **2-3 hrs**

2-10 mm hgt



Anurans:



- Ascaphidae
- Fast-flowing streams
- Cloacal extension: "tail"
- "Tail" at 90 degree angle
- Male in "sitting" position
- Copulation occurs for **24-30 hrs**
- Cloacal Apposition
- E. coqui* and *jasperi*



Salamanders:

- Spermatophore stores in spermatheca
- Sperm can be stored for >2 yrs (some)
- Ovulation stimulates sperm

- Lentic:
 - Twigs, Leaves (O₂)
 - Newts wrap eggs!
- Lotic:
 - Under stones (single)
 - Stream banks
- Terrestrial:
 - Under stones, logs or within logs
 - Female protects

Cost of Reproduction

Túngara frog (*Engystomops pustulosus*)



Males

- Sperm
- Calling
- Territorial Defense
- Amplexus

3.25 kJ = Calling Males

1.02 kJ = Satellite Males

(Ryan 1985)

Females

- Eggs
- Locate Suitable Male

~10,000 calories
40.96 kJ

45.99 kJ *Eleutherodactylus coqui*
(Woolbright 1985)

•Female Investment: **20X Greater**

Some Species Multiple Clutches per Year

Explosive Breeders
(favorable years)

•Predation Risk: **Greatest for Calling Males**

Age of 1st Reproduction
1 yr = most anurans
≥2 yr = most caudates
