Amphibian Courtship and Mating: Anuran Focus

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Goal of the Lecture

To familiarize students with amphibian courtship and mating strategies.

Reading Assignments:

1) **See Website:** Wells (2007)
2) **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

Finding a Mate

Two cues are needed to orienteer (Sinsch 1990)

Cues Used to Find Conspecifics

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
  - R-B 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

5) Geotactic or Hygrotactic Cues
- Migrate downhill and toward moisture
- Non-random dispersal to and from wetlands

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

Mechanics of the Typical Anuran Call

100 dB

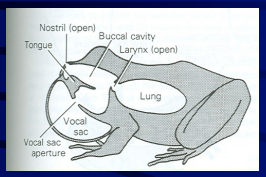
Pipidae Exception

Rapid Contraction of Laryngeal Muscles

1) Inhale Lungs

2) Close Nares

3) Contract Trunk Muscles
- Oblique Muscles



4) Larynx (vocal cords)
- Muscular energy → acoustic energy
- Single notes: inhale every time
- Multiple Pulses: resonate & trunk muscles may periodically contract

5) Buccal Cavity

6) Vocal Slits

7) Vocal Sac
- Resonates Sound

8) Nares Open

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

Types of Vocal Sacs

1) Median Subgular
- Single Sac in Throat
- Most Common

2) Paired Subgular
- Two Sacs in Throat
- Partially or Completely Separated

3) Paired Lateral
- Behind & Below Jaw

Internal

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

#2 and #3

External

#1 and #2

- Skin modified: Thin and Folded

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

Hybrid Calls
Both Characteristics
- *H. cinerea* x *H. gratiosa*

Genetic Basis!!

D) Compound Advertisement

Combines both A and B

"Co": B
"qui": A

Eleutherodactylus coqui

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

➢ Unison Bout Calling

Increase call rate when female is detected

- 10-20 sec call once per minute
- 5 second interval between calls

3) Long Calls and Fast Rates

Females prefer longer calls @ faster rates

- Often correlated with body size

Long, Slow over Fast, Short

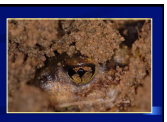
4) Chorus Leaders

- Females attracted to speaker that initiated chorus

5) Satellite Males

- Smaller Males
- Intercept Females

Factors Influencing Advertisement Calls



1) Temperature

- Linear relation with call and pulse rates
- Relation decouples toward end of BS (ē)

•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
  - ➢Similar tone w/ gradual modulation

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 Dentrobatids
- ➢Some don't call (e.g., Ascaphus)

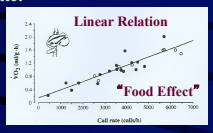
5) Food Resources (Grafe 1996)

- ➢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

Energetics of Advertisement Calls

The MOST energetically demanding activity of a male frog!

Oxygen Rate:



2-3 hrs per night

3300 notes per hour

Pough et al. (1992)

Energy Expended:

Species	J/hr	J/hr/g
H. gratiosa	280	22
H. versicolor	280	33
H. cinerea	80	16
P. crucifer	25	21

≈40 cal/hr or ≈100 cal/night

Energy Comparison:

Activities	Calling > Activity
Foam nest	1.5X
Burrowing	3X
Foraging	4X
Resting	10X

Secondary Sexual Characteristics

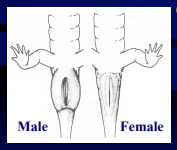
Salamanders:

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:

Triturus vulgaris

- •Aquatic Salamanders
  - ▪Salamandridae
  - ▪Ambystomatidae
- •Males larger

4) Head Glands:

5) Nuptial Excrescences:

- ▪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

2) Vocal Sac: (external spp)

3) Eggs:

Species with clear ventral skin

4) Nuptial Excrescences:
- ▪Keratinized Epidermis
- ▪Stimulate ovulation

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

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

Amphibian Courtship

Olfactory and visual cues

Salamanders:
- •Hynobiids, cryptobrachids, 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

Lunglessness
- ▪Aquatic
  - •>2 hrs (often)
  - •>1 courtship seq. (often)
  - •Water quality can affect courtship bouts
  - •Ė limited (likely)!

Anuran Courtship

In general, NOT elaborate!

1) Advertisement Calls
- •Primary Courtship Cue
- •Male Generally Calls until Nudged

- •Female positions for amplexus
- •Preamplectic 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. olivacea*
Former: females larger

- •Skin Texture

Explosive Breeders & Satellite Males

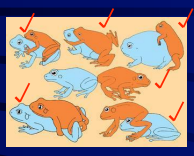
"No release call!"

Types of Amplexus

Anurans

Duration: 1-2 hrs

Vents not Juxtaposed



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

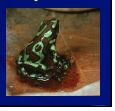
Anurans:

Aquatic Oviposition — Clutch >100

- 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

Arboreal Oviposition — Clutch <50

- 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 (all):

- Phallodeum: 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

Anurans:

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

Salamanders (90%):

2-10 mm hgt

Polysaccharides

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

Lentic:	▪Twigs, Leaves (O_2)
	▪Newts wrap eggs!
Lotic:	▪Under stones (single)
	▪Stream banks
Terrestrial:	▪Under stones, logs or within logs
	▪Female protects