


# 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

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## Lecture Structure

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

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Two cues are needed to orienteer (Sinsch 1990)


## Finding a Mate

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

### Importance

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

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100 dB  
(~90 Damage)


## Mechanics of the Typical Anuran Call

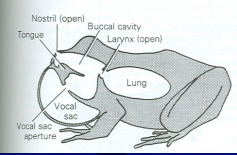
### 1) Inhale Lungs

### 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

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## Types of Vocal Sacs


### 1) Median Subgular

- Single Sac in Throat
- Most Common



### 2) Paired Subgular


- Two Sacs in Throat
- Partially or Completely Separated



*Pteronohyla 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

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## 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

**D) Compound Advertisement**  
Combines both A and B

*G. Krupa*

*Eleutherodactylus coqui*

"Co": B  
"qui": A


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## 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





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## 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

**4) Chorus Leaders**  
•Females attracted to speaker that initiated chorus

**5) Satellite Males**  
•Smaller Males  
•Intercept Females





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## Factors Influencing Advertisement Calls



### 1) Temperature

- Linear relation with call and pulse rates

**•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
- 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

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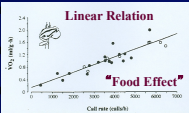
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## Energetics of Advertisement Calls

### The MOST energetically demanding activity of a male frog!

#### Oxygen Rate:



**Linear Relation**  
2-3 hrs per night  
3300 notes per hour  
Pough et al. (1992)

#### Energy Expended:

Species	J/hr	J/hr/g
<i>H. gratioiosa</i>	280	22
<i>H. versicolor</i>	280	33
<i>H. cinerea</i>	80	16
<i>P. crucifer</i>	25	21

~40 cal/hr or ~100 cal/night

#### Energy Comparison:

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

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## 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 Exerescences:

- 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 3<sup>rd</sup> finger (*Colostethus*)
- Tusks or spines (some families)
- Hair-like projections (*Trichobatrachus robustus*)



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## Anuran Courtship

**In general, NOT elaborate!**

### 1) Advertisement Calls

- Primary Courtship Cue
- Male Generally Calls until Nudged



G. Krupa

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



### 2) Conspecific Recognition

**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!

Tactile Cues

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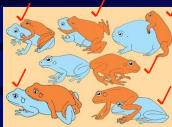
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## Types of Amplexus


Anurans



Inguinal



Cephalic



Axillary

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

Duration:  
1-2 hrs

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## 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



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## 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%):**



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

**Oviposition Sites:**

**Lentic:** • Twigs, Leaves (**O<sub>2</sub>**)  
• Newts wrap eggs!

**Lotic:** • Under stones (single)  
• Stream banks

**Terrestrial:** • Under stones, logs or within logs

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