

Amphibian Predation and Defense

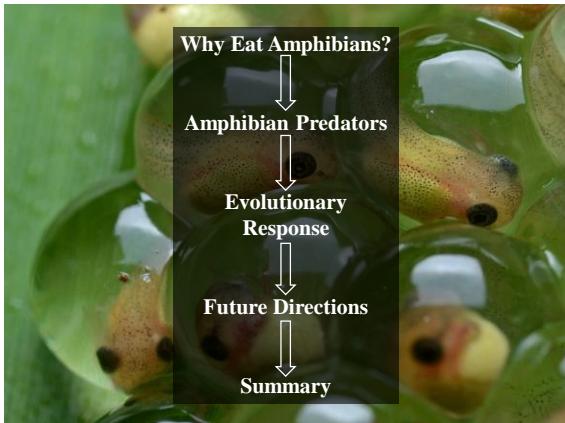


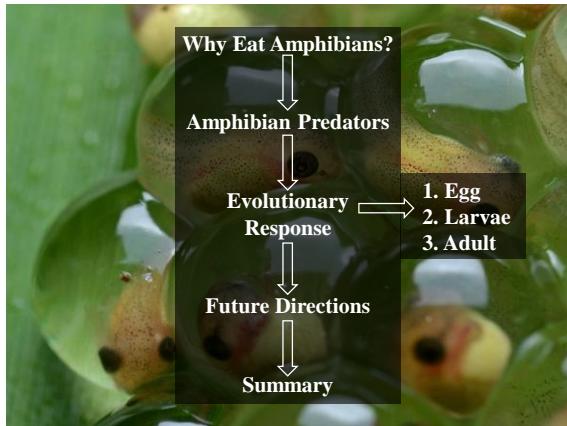
By: Katie Harris



“Each stage of development from egg to adult faces its own particular dangers, and at no time of day or night are frogs and their offspring safe from attack.” – Tyler 1976

“almost anything will eat an amphibian.” – Porter 1972





Why eat an amphibian?

- Small, slow-moving, defenseless?
- High population densities
- Good source of protein
- Lack indigestible material

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Common Predators?



Common Predators?

- Invertebrates
 - eggs and larvae
 - temporary ponds
 - caddisfly larvae
 - parasites
 - trophic loop



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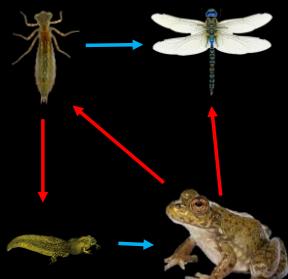
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Common Predators?

- Invertebrates
- Fish
 - Eggs, larvae, adults



Common Predators?

- Invertebrates
- Fish
- Reptiles



Common Predators?

- Invertebrates
- Fish
- Reptiles
- Birds



Common Predators?

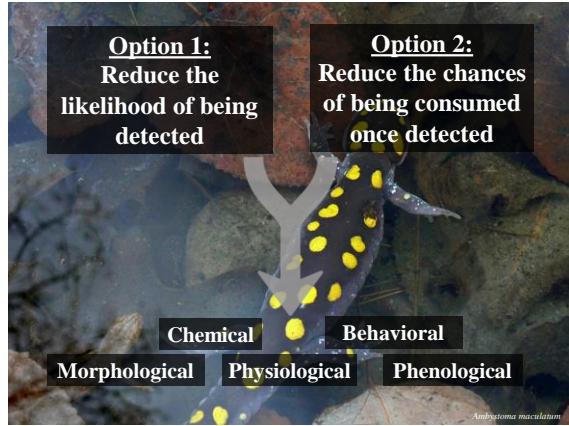
- Invertebrates
- Fish
- Reptiles
- Birds
- Amphibians

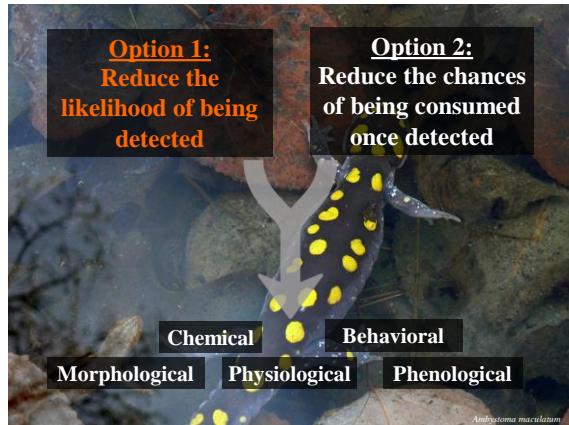


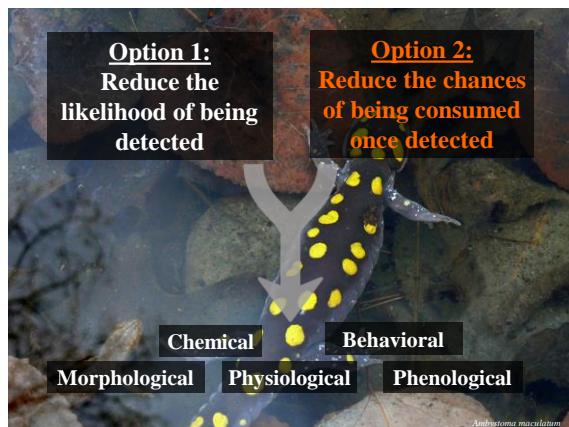
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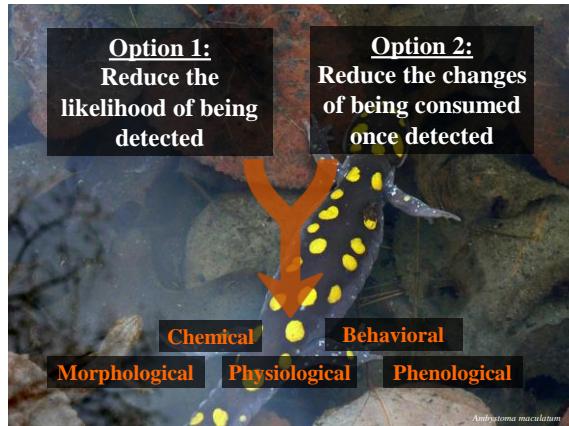
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- Fish
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- Birds
- Amphibians
- Mammals











Eggs: Mechanical and Chemical

- Egg capsule and jelly
- Toxic and distasteful compounds
- Effectiveness depends on predator
 - Eggs of *R. californicus* & *R. catesbeianus*
 - distasteful to newts and larval ambystomatids (Walters 1975)
 - readily consumed by leeches (Howard 1978)

Eggs: Oviposition Site

- Areas without fish
 - temporary ponds
 - on land
- Areas void of predators
 - *Anaxyrus americanus* avoid oviposition in areas that contained *Lithobates sylvaticus* eggs (Petraska et al. 1994)
 - *L. sylvaticus* didn't lay eggs in ponds with predatory sunfish (Hopyan and Petranka 1994)

Lithobates sylvaticus

Eggs: Oviposition Site



Lithobates sylvaticus

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Eggs: Timing of Reproduction



Lithobates sylvaticus

- Early spring
 - before predatory species reach peak densities
- Synchronized reproduction
 - earlier hatchlings consume eggs deposited later
 - swamp predators increasing individual survival

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Eggs: Adaptive Plasticity

- Red-eyed tree frog (*Agalychnis callidryas*)
 - egg mass hatches immediately if clutch is attacked (Warkentin 1995, Warkentin 2000, Warkentin et al. 2001)
 - survive by dropping in water
 - trade off! → small, not very mobile
 - wasp predation – single hatching (Warkentin 2000)
 - fungus – eggs closest to fungus hatch first



Agalychnis callidryas

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Lepidoderm

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Palpilia variata

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Eggs: Adaptive Plasticity

- Hatching is delayed in the presence of predators (Sih and Moore 1993, Moore et al. 1996)
 - Allows larvae to hatch at a more advanced stage



Larval Defense:



Larval Defense: Color Patterns

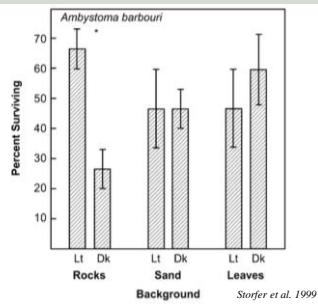
- First line of defense
 - Drab colors
 - Countershading
 - Disruptive coloration
 - Reflective or transparent
 - Deflection marks



Lithobates clamitans

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Lithobates catesbeianus

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100

Larval Defense: Phenotypic Plasticity

- *Acris*
 - tail tip coloration (Caldwell 1982)
 - *Hyla chrysoscelis*
 - dragonfly naiads present
 - dark orange, deep tail fins, dark
(Van Beek & McAllister 1999)
 - predators absent
 - Shallow, unmarked tail fins
(Van Beek & McAllister 1999)
 - early age exposure = gradual development (LaFlamme & Babbitt 2004)
 - direct contact not necessary



in present

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 - direct contact not necessary



Present

Larval Defense: Phenotypic Plasticity

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 - tail tip coloration (Caldwell 1982)
 - *Hyla chrysoscelis*
 - dragonfly naiads present
 - dark orange, deep tail fins, dark
(Van Beek & McCallum 1999)
 - predators absent
 - yellow, unmarked tail fins
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 - early age exposure = gradual development (LaFondra & Rohrbach 2004)
 - direct contact not necessary



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Larval Defense: Behavioral

- **Schooling** (Rödel and Lintemaur 1997)
 - decreases chance of individual capture
 - **Time of day**
 - shift active when predators are not active (Sih et al. 1992)
 - *Ambystoma barbouri* – tend to be nocturnal in presence of fish (Taylor 1983)
 - **Refuge habitats: less food**
 - water column – *Ambystoma talpoideum* (Holomuzki 1986)
 - trade-offs → vulnerability versus foraging efficiency
 - **Limit activity** (Altwegg 2003)



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Lithobates sylvaticus

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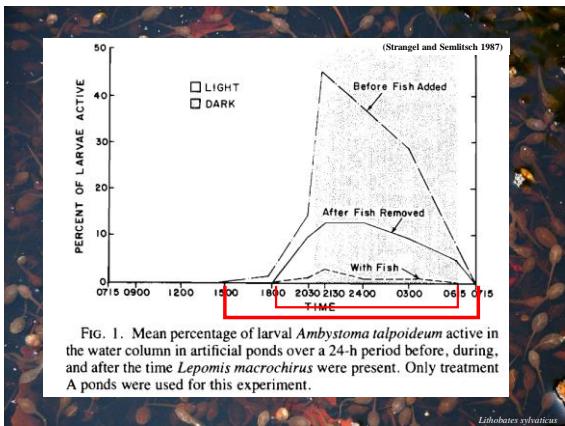
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Larval Defense: Sensory Cues

- Tactile
- Visual
- Chemical
 - discrimination between dangerous and less dangerous genetic response-previous exposure is not required (Lekkerier 1996, 1998; Gallie et al. 2001; Matilo et al. 2003)
 - discrimination between predators of conspecific larvae (Chivers and Mira 2001)
 - not always present, can develop rapidly (Kiesecker and Blaustein 1997)

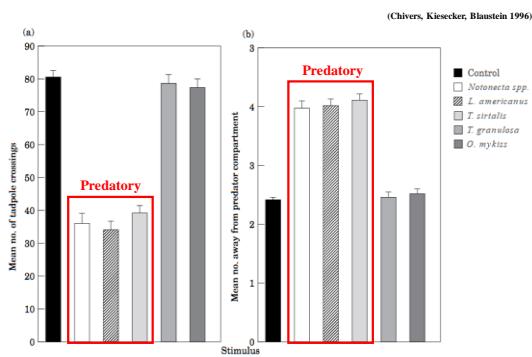


Figure 1. Mean + se (a) number of tadpole crossings and (b) number of individuals away from the predator compartment for tadpoles exposed to both chemical and visual cues of stimulus animals, based on 10 replicates for each treatment.

Larval Defense: Sensory Cues

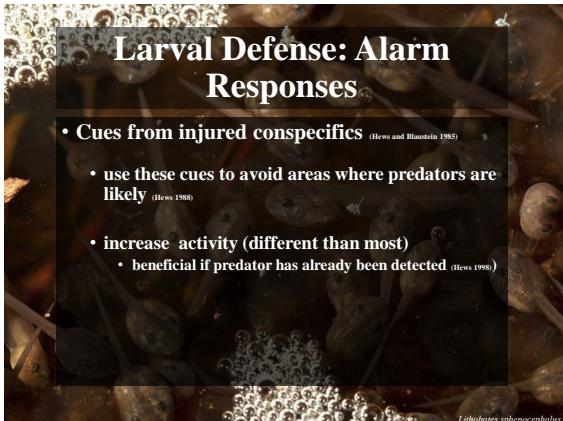
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Lithobates sylvaticus

Larval Defense: Alarm Responses

- Cues from injured conspecifics (Hews and Blaustein 1985)
 - use these cues to avoid areas where predators are likely (Hews 1988)
 - increase activity (different than most)
 - beneficial if predator has already been detected (Hews 1998)



Lithobates sphenocephalus

Larval Defense: Growth & Development

- Rapid growth
 - Predators have limited prey size
 - Sprint speed increases with size (Richards and Bell 1990)
 - Higher growth rate = higher survivorships (Travis 1985)
 - Growth and predator exposure
 - *Bufo boreas* – increased growth rate (Chivers et al. 1999)
 - *Ambystoma macractylum* – decreased growth rate
 - foraging decreased (Widéy et al. 1999)



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Larvae Defense: Chemical Defenses

- Distasteful and toxic; particularly anuran tadpoles
 - *Bufo* - palatability varies among predators
- Why not in all species?

Bufo bufo

Larvae Defense: Chemical Defenses

- Distasteful and toxic; particularly anuran tadpoles
 - *Bufo* - palatability varies among predators
- Why not in all species?
 - expensive to produce
 - temporary ponds: too costly, rapid growth
 - permanent ponds: worth the energy costs, slow growth

Bufo bufo

Adult Defense: Cryptic Coloration



Hyla chrysotica

- Matching dorsal coloration to environment (Edmonds 1974)
- Reflect light in visible and infrared spectrum (Schulz et al. 1997; Emerson et al. 1990)
- Color change (Iipa and Ragaara 1975)
- Cryptic patterning (Cott 1940)

Adult Defense: Cryptic Coloration



Hyalinobatrachium taylori

- Matching dorsal coloration to environment (Edmonds 1974)
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Adult Defense: Cryptic Coloration



Hyla cinerea

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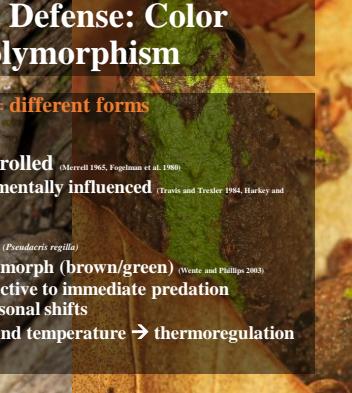
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Ceratobatrachus guentheri - Solomon Island Frog

Adult Defense: Color Polymorphism

- Polymorphism = different forms
- Genetically controlled (Merrell 1965, Fogelmann et al. 1980)
 - can be environmentally influenced (Travis and Trexler 1984, Hurley and Sennittich, 1988)
- Pacific tree frog (*Pseudacris regilla*)
 - color-changing morph (brown/green) (Wente and Phillips 2003)
 - slow → not effective to immediate predation
 - adaptive → seasonal shifts
 - light intensity and temperature → thermoregulation (Stegnilev et al. 2004)



Acris crepitans

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Acris crepitans

Adult Defense: Predator Avoidance

- Avoid locations where predators present
- Chemical cues
 - predators
 - injured conspecifics
- Newts (Woody and Mathis 1998)
 - did not avoid chemical stimuli from fish (Marvin and Hutchinson 1995, Woody and Mathis 1997)
 - avoided chemical stimuli from fish if associated with injured conspecific (Woody and Mathis 1998)

Plethodon vanderkelleni

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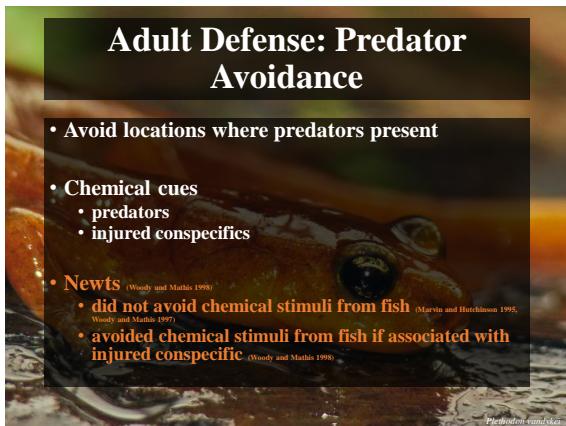
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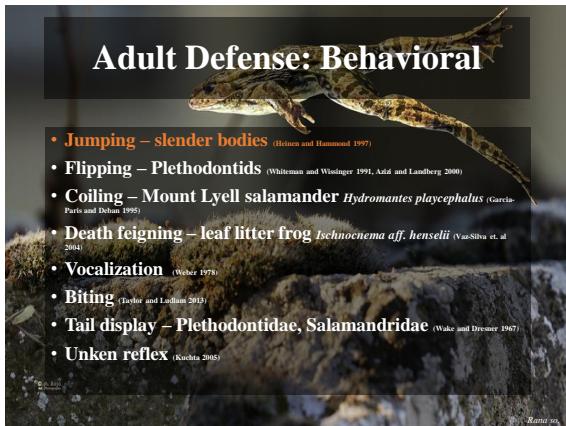
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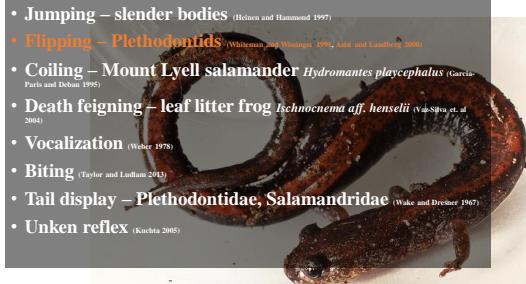
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- **Jumping – slender bodies** (Heinen and Hammond 1997)
 - **Flipping – Plethodontids** (Whiteman and Wissinger 1991, Aizd and Landberg 2000)
 - **Coiling – Mount Lyell salamander** *Hydromantes playcephalus* (Garcia-Paris and Debus 1995)
 - **Death feigning – leaf litter frog** *Isthocnema aff. henselii* (Vaz-Silva et. al 2004)
 - **Vocalization** (Weber 1978)
 - **Biting** (Taylor and Ladum 2013)
 - **Tail display – Plethodontidae, Salamandridae** (Wake and Dresler 1967)
 - **Unken reflex** (Kuchta 2005)



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Lithobates catesbeianus







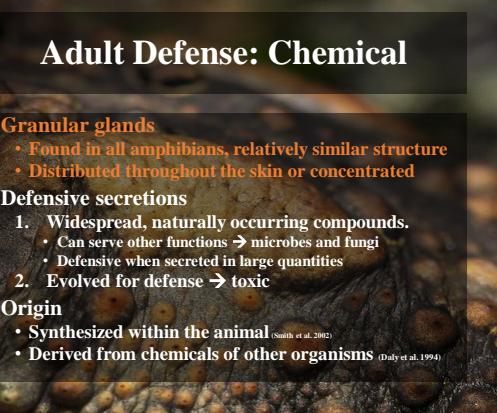
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- Unken reflex (Krohn 2005)

Taricha granulosa

Adult Defense: Chemical



- Granular glands
 - Found in all amphibians, relatively similar structure
 - Distributed throughout the skin or concentrated
- Defensive secretions
 1. Widespread, naturally occurring compounds.
 - Can serve other functions → microbes and fungi
 - Defensive when secreted in large quantities
 2. Evolved for defense → toxic
- Origin
 - Synthesized within the animal (Smith et al. 2002)
 - Derived from chemicals of other organisms (Daly et al. 1994)

Anatyrus sp.

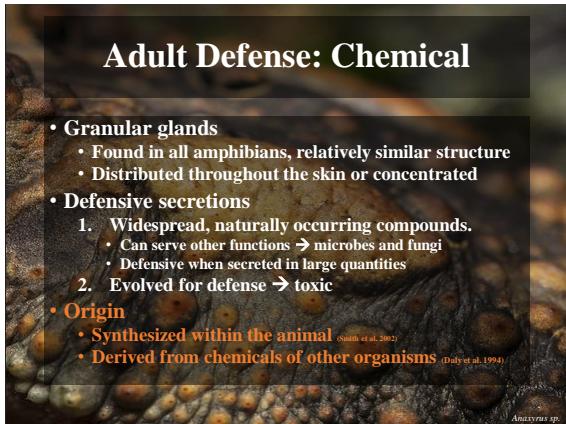
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Adult Defense: Aposematic Coloring



Hyla chrysoscelis

- Coloration to warn or deter predators
- Only beneficial when predator can see colors
- Dendrobatidae
 - Color brightness correlates to toxicity (Summers and Cough 2001)

Adult Defense: Mimicry



Notophthalmus viridescens *Pseudotriton ruber*

- Predators learn to avoid the aposematic patterns
- Batesian mimicry: edible species benefit by evolving pseudoaposematic colors
- *Pseudotriton ruber* & *Notophthalmus viridescens*
 - readily eaten before exposure to red efts (Brodie & Howard 1972)
 - less palatable than *Desmognathus* species (Brandon et al. 1979)
 - produce toxins → Mullerian
- Mullerian mimicry: toxic species share a common warning coloration

Future Directions

- Impact on populations
 - demographic impact of predation
 - impact of specific predators
 - invasive predators
 - Genetics
 - Relationships between toxicity and predators
 - Caecilians and salamandersThree small illustrations of amphibians and a lizard are arranged horizontally. From left to right: a brown snake coiled in a S-shape; a green frog with a light belly; and a brown lizard with a long tail.



Lithobates sylvaticus

Summary

- Subject to vast array of predators
 - Predation is greatest on egg and larval stages
 - Most predators are generalists
 - Protection against predators is varied
 - Predation lessened by:
 - reduce the chance of detection
 - reduce the changes of being consumed once detected
 - chemical, phenological, behavioral, physiological, morphological



Eusatina eschscholtzii

References

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