Amphibian Population Declines and Malformations

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Global Amphibian Declines


Worldwide Amphibian Population Declines
History of Amphibian Declines

Prior 1970s: Few extinctions; some localized die-offs

1970-mid-1980s: Few extinctions, localized die-offs in temperate areas associated with habitat destruction

Late 80s-Now: Increase in extinctions, localized & regional die-offs in temperate and tropical areas; some in “pristine” areas

Ohio Journal of Science 49:70-71
Alberta Naturalist 11:1-4


Status of Amphibian Populations

United States:
- 1 Species Extinct (Rana fisheri) Western U.S.
- 10 Endangered; 7 Threatened; 8 Awaiting
- CA: 7 Spp. (Sacramento V.); 5 Spp. (Yosemite)
- AZ: 7 Spp. (Chiracahua Leopard Frog)

Puerto Rico:
- 18 spp. (16 coquis)
- 61% spp. in Caribbean
- 2 Spp. Extinct (Golden and web-footed Coquis)
- 1 Spp. of Toad; 2 Spp. Coquis
- 8 Spp. Extinct; 6 Spp. in Serious Decline
- Gastric-brooding Frogs
- (Discovered in ’70s)
- 1 Spp. Extinct (Golden toad)
- Unknown in Decline

Australia:
- Elevation
- Costa Rica:
- Pristine

Amphibian Conservation Entities

Declining Amphibian Populations Task Force (DAPTF)
- Established in 1991 after 1989 First World Congress of Herpetology
- Partnership, Research, FROGLOG
- 30 Scientists, 90 Countries
- 5 Prongs:
  - Call Surveys***
  - Terrestrial Salamander
  - Aquatic Surveys
  - Atlassing
  - Western Surveys

USGS 1995
- Voluntary
- Working Groups

To determine the nature, extent, and cause of worldwide amphibian declines, and promote efforts to reverse current population trends

To determine the current population status on NA amphibians

IUCN
### Basic Amphibian Biology

**Exothermic vertebrates with a biphasic (in part) life cycle**

- Thin, Permeable Skin that must remain Moist
  - Respiration
  - Osmoregulation

- Low Vagility (<1 km)
- Long-lived (ca. 10 yr)

**Desiccation a Lifelong Struggle**

- Water is a Necessity
  - Behaviorally Hydroregulate
  - Aestivation

**Mesozoic Era (150 m. yrs.)**

**Amphibian Population Structure**

**Metapopulation**

- Isolated Demes (Subpopulations)

- Population Demography is Influenced by Interdemic Movements (Dispersal)
  - Genetically: Increasing Individual Heterozygosity
  - Numerically: Reducing Susceptibility of Demes to Demographic or Environmental Stochasticities

**Species-Specific Vagility**

**Landscape Physiognomy & Connectivity**

**Hypotheses Related to DIRECT Anthropogenic Effects**
### Habitat Destruction/Degradation Hypothesis

**#1 Cause of Amphibian Declines**

**Seemingly, Obvious:**
- Logging Practices
- Agricultural Practices
- Cultivation, Grazing
- Urban Development & Roads

**Not so Seemingly, Obvious:**
- Sedimentation
- Altered Hydroperiods
- Wildlife Management
- Burning, Mowing

### Chemical Pollution Hypothesis

**Point Source:** Pollution originating from 1 point.
- Effluent: organic or industrial waste
- Thermal: electric plants

**Non-point Source:** Pollution originating from multiple points (e.g., field, parking lot).

**Chemicals & Effects:** Tolerance
- Nitrates & Ammonia: Direct mortality; Reduce growth
- Organophosphate Insecticides: Above plus malformations and altered behavior; bioconcentration
- Various Oils & Compounds: Affect respiration

### Introduced Predators & Competitors Hypothesis

**Predators:**
- Fish (eat everything)
- Sport Fish (e.g., trout, bass)
- Bullfrogs (eat everything but adults)
- Fire Ants (eat metamorphs)

**Competitors:**
- Frogs
- *Bufo marinus, Rana catesbeiana*
- Bait & Mosquito Fish
- Crawfish (Predator of eggs also)
Commercial Exploitation Hypothesis
Traditionally a Concern in the Orient

**Removal:**
- 200 million exported annually from Asia
- 70 million exported annually from India

**Release:**
(Exotics or captive-reared specimens)
- 9 million frogs (*Rana*) shipped from biological supply companies in the USA

**Reintroduction:**
- Pathogens
- Regional Genetic Structure

Environmentalist 10:39-41, 1990
Bioscience 21:1027-1034

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Hypotheses Related to INDIRECT Anthropogenic Effects

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Global Warming Hypothesis
The anthropogenic increase of ambient temperatures via the accumulation of “greenhouse” gases

**Consequences of Greenhouse Effect**
- Severity of Weather
- Direct Alteration of Habitat
  - Altitudinal/Latitudinal
  - Specialist (K-Selected)

Climate Change 39:541-561
UV-B Radiation Hypothesis

Ozone depletion has resulted in increased incidence of UV-B radiation with the surface of Earth

Effects on Amphibians
- Direct Mortality
- Decrease Hatching Success***
- Malformations

Most Susceptible Amphibians:
- Low Photolyase in Eggs
- Eggs Near Surface
- Higher Elevation

Blaustein
Photochemistry & Photobiology
64:449-456
Conservation Biology 10:1398-1402

Acid Precipitation Hypothesis

The anthropogenic decrease in pH of precipitation via emissions of nitrogen oxides and sulfur dioxide and their oxidation and dissolution to acids

Effects on Amphibians
- Direct Mortality
- Delayed Hatching
- Reduced Mobility
- Reduced Larval GR & Size

Copeia 1986:454-466

Pathogenic Hypothesis: Fungi

Chytrid (Ki-trid) Fungus

Circumpolar Non-hyphal, Parasitic Fungus
Phylum: Chytridiomycota Unicellular
Class: Chytridiomycetes Most Haploid: Zoospores
Order: Chytridales

Colonize Keratinized Epidermal Cells (Mouth & Pelvic Patch)

Introduced

Effects on Amphibians
- 50-100% Direct Mortality
- Epidermal Hyperplasia ➔ Sloughing
- Interference w/ Cutaneous Respiration & Osmoregulation

Batrachochytrium dendrobatidis
Phylum: Chytridiomycota
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Pathogenic Hypothesis: Iridovirus

- dsDNA, 150-280K bp
- 120-300 nm in diameter (3x smaller than bacteria)
- Icosahedral Shape (20)

Crystal Packing Gives Infected Cells Blue Iridescence

Australia, CO, CR

Family: Iridoviridae
Genus: Ranavirus & Species: FV3

Symptoms:
1) Dermal ulcerations and edema
2) Systemic hemorrhages

Phil. Trans. R. Soc. Lond. 351:1539-1557

Pathogenic Hypothesis: Bacteria

Generally Secondary to Viral and Fungal Infections

*Aeromonas hydrophila*

- Ubiquitous
- Oxidase-positive
- Facultatively Anaerobic
- Gram-negative

Neg. Corr. w/ WBC

Found in Fresh and Saltwater

Enters host via Ingestion

Associated w/ "Stress"

Effects on Humans: gastroenteritis & septicemia

Effects on Amphibians: Red Leg
1) Stop Eating
2) Septicemia
3) Capillary Dilation
4) Petechial Hemorraging

Pathogenic Hypothesis: Parasites

*Trematodes* (Ribeiroia metacercaria)

41 spp.

Effects on Amphibians:
1) Cysts form in and around "limb-buds"
2) Limb Development
3) Malformations

Survival/Reproduction

Science 284:802-804
The Synergistic Hypothesis

- Likely a Synergy of Anthropic Effects
- Habitat
- Pathogen
- Invasive Species
- Exploit
- Pollution
- UVB
- Local Population Loss increases Probability of Metapopulation Extinction
- Global Warming
- Some Factors may Suppress Immune System via “Stress”
- Some Factors may increase Toxicity/Virulence of other Factors

Annu. Rev. Ecol. Syst. 30:133-165

Amphibian Malformations

- History of Amphibian Malformations
  - New County Middle School
  - LeSueur, MN
  - August 1995
  - Cindy Reinitz
  - July 1996
  - 175 Reports, 2/3 Counties in MN
  - Turn-road bordered by corn and soybean field
  - 50% Deformed
  - Similar Reports emerged, especially in WI and Western States
Locations of Confirmed Malformations in North America

Brewster, Burleson, Liberty, and Harris
1) 1999: 1.5% JUV; 3% AD
2) 2000: ??? (ca. 25% w/ TGSL)

Hale, Crosby, Floyd, Castro

Examination of Malformation Hypotheses

Stanley K. Sessions, Ph.D.
Department of Biology
Hartwick College, Oneonta, NY

Science 284:800-802; Science 284:802-804
Journal of Experimental Zoology 254:38-47

http://www.hartwick.edu/biology/def_frogs/

Chemical Pollution Hypothesis

Retinoids

Family of biochemicals (including vitamin A) that are important in embryonic development

Why not Retinoids?
1) Lack of geographic correlation
2) Exogeneous RA have to be excessively high
3) Proximal-distal Duplication
4) Affects all organisms equally
5) Affects limbs equally (hind)
6) Symmetrical Deformities 7) Bony Triangle

Excess $\rightarrow$ Teratogen

Methoprene IGH
UV-B Radiation Hypothesis

Less than ambient UV (~70%) at constant exposure can cause deformities

Why not UV-B?
1) Bilateral and Symmetrical Deformities
2) Presence of Cartilaginous Spike

Eukaryotic Parasite Hypothesis

Trematodes
(Ribeiroia metacercaria)

Why Trematodes?
1) Cause all classes of deformities
   PDD, PMID, AMID, MIT
2) Cause bony triangles & cutaneous fusions
3) Empirical FIELD evidence

Predation/Cannibalism Hypothesis

Dave Pfennig

Associated with missing limbs and limb parts
Asymmetrical Limb Truncation
After Regenerative Decline
Amphibians: The Organism and Community

Should we be Concerned??
ABSOLUTELY!!!
“The Singularity of Amphibians”

- Good Ecological Indicators
- Important Components of Ecosystems
- Unknown Medicinal Uses
- Comprise Significant Biomass
- Very Efficient (95%)
- Long-lived (10 yrs.)

What can you do?

**Amphibian Population Declines**
Participate in Surveys
National: naamp@usgs.gov
Texas: Lee Ann Linam; 512-847-9480
lalinam@wimberley-tx.com

**Amphibian Malformations**
Report Malformations
Form: http://www.npwrc.usgs.gov/narcam/
Email: narcam@usgs.gov