

Amphibian Population Declines and Malformations



Bufo perigrinus, CR



Hyla regilla, OR

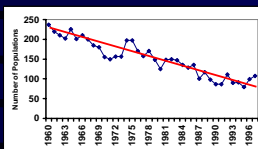
Matthew J. Gray
University of Tennessee

Worldwide Amphibian Population Declines

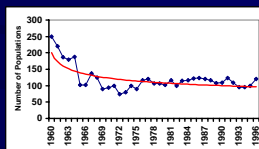
Global Amphibian Declines

Houlahan et al. 2000, *Nature* 404:752-755

North America



Western Europe



History of Amphibian Declines

Prior 1970s: •Few extinctions; some localized die-offs
Ohio Journal of Science 49:70-71

1970-mid-1980s: •Few extinctions
•Localized die-offs in temperate areas associated with habitat destruction
Alberta Naturalist 11:1-4

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

Conservation Biology 7:355-362, 8:72-85, 10:406-413, 10:414-425, 12:106-117, 13:117-125; Biotropica 20:230-235; Nature 404:752-755

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. (Chiricahua Leopard Frog)

Puerto Rico: •2 Spp. Extinct (Golden and web-footed Coquis)
18 spp. (16 coquis)
61% spp. in Caribbean

Australia: •1 Spp. of Toad; 2 Spp. Coquis
•8 Spp. Extinct; 6 Spp. in Serious Decline
➔ Gastric-brooding Frogs
(Discovered in '70s)

Costa Rica: •1 Spp. Extinct (Golden toad)
•Unknown in Decline



Amphibian Conservation Entities

Declining Amphibian Populations Task Force (DAPTF)

•Established in 1991 after 1989 First World Congress of Herpetology IUCN

•3000 Scientists, 90 Countries •Partnership, Research, FROGLOG

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

North American Amphibian Monitoring Program

To determine the current population status on NA amphibians


5 Prongs: •Call Surveys*** •Atlassing USGS
•Terrestrial Salamander •Western Surveys 1995
•Aquatic Surveys Working Groups

Voluntary

Basic Amphibian Biology

Mesozoic Era
(350 m. yrs.)

Water is a Necessity



Behaviorally Hydroregulate

Aestivation

Exothermic vertebrates with a biphasic (in part) life cycle


- Thin, Permeable Skin that must remain **Moist**
 - 1) Respiration
 - 2) Osmoregulation
- Low Vagility (≤ 1 km)
- Long-lived (ca. 10 yr)

Desiccation a Lifelong Struggle

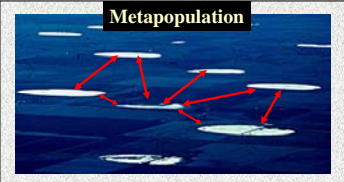
Absorb Compounds Readily

Amphibian Population Structure


Species-Specific Vagility



Metapopulation



Landscape Physiognomy & Connectivity



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

Hypotheses Related to DIRECT Anthropogenic Effects


Habitat Destruction/Degradation Hypothesis W1

#1 Cause of Amphibian Declines

Seemingly, Obvious:

- Logging Practices
- Agricultural Practices
- Cultivation, Grazing
- Urban Development & Roads


54% Wetlands Loss



Not so Seemingly, Obvious:

- Sedimentation
- Altered Hydroperiods
- Wildlife Management
- Burning, Mowing

Ray Semlitsch



Chemical Pollution Hypothesis L3

Point Source: Pollution originating from 1 point.

- **Effluent:** organic or industrial waste
- **Thermal:** electric plants

Repositories

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

Chemicals & Effects:

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

Tolerance

Sub-Lethal

Food Web

Introduced Predators & Competitors Hypothesis L2



Predators:

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

Copeia 1999:22-23
Copeia 1991:1-8
SARI Spec. Pub. 1

Competitors:

- Frogs
 - ➔ *Bufo marinus*, *Rana catesbeiana*
- Bait & Mosquito Fish
- Crawfish (Predator of eggs also)

Commercial Exploitation Hypothesis

Traditionally a Concern in the Orient

L3

Removal: •200 million exported annually from Asia

•70 million exported annually from India

Environmentalist
10:39-41, 1990

→ Consumption, Pet Industry

Release: (Exotics or captive-reared specimens)

Bioscience
21:1027-1034

•9 million frogs (*Rana*) shipped from biological supply companies in the USA

→ Science

Reintroduction: •Pathogens

Conservation
Biology 8:60-71

•Regional Genetic Structure

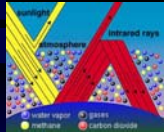
Hypotheses Related to INDIRECT Anthropogenic Effects

Global Warming Hypothesis

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

W3

CO₂, N₂O, CH₄



Climate Change
39:541-561

Consequences of Greenhouse Effect

•Severity of Weather

•Direct Alteration of Habitat
Altitudinal/Latitudinal

→ Specialist (K-Selected)



Catastrophic
Events

UV-B Radiation Hypothesis

W1

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

Synergy

Blaustein



Effects on Amphibians

- Direct Mortality
- Decrease Hatching Success***
- Malformations

Most Susceptible Amphibians:

Photochemistry & Photobiology
64:449-456

Conservation Biology 10:1398-1402

•Low Photolyase in Eggs

•Eggs Near Surface

•Higher Elevation

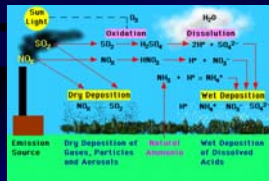
Vegetation

Acid Precipitation Hypothesis

W3

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

pH < 4



Effects on Amphibians

- Direct Mortality
- Delayed Hatching
- Reduced Mobility
- Reduced Larval GR & Size



Copeia 1986:454-466

Food Web

Synergy

Pathogenic Hypothesis: Fungi

Chytrid (*Kl-trid*) Fungus

L1

Circumpolar

Non-hyphal, Parasitic Fungus

Phylum: Chytridiomycota

Unicellular

Class: Chytridiomycetes

Most Haploid: Zoospores

Order: Chytridiales

Batrachochytrium dendrobatidis

Colonize Keratinized Epidermal Cells

(Mouth & Pelvic Patch)

Introduced

Effects on Amphibians

•50-100% Direct Mortality


Epidermal Hyperplasia → Sloughing

→ Interference w/ Cutaneous Respiration & Osmoregulation


Proc. Natl. Acad. Sci.
95:9031-9036



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
- Facultatively Anaerobic

- Oxidase-positive
- Gram-negative

Neg. Corr. w/ WBC

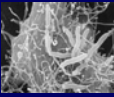
Found in Fresh and Saltwater
Enters host via Ingestion

Associated w/ "Stress"

Effects on Humans: gastroenteritis & septicemia

Effects on Amphibians: **"Red-Leg"**

- 1) Stop Eating
- 2) Septicemia
- 3) Capillary Dilation
- 4) Petechial Hemorrhaging

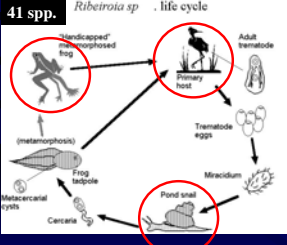


Pathogenic Hypothesis: Parasites

Trematodes

(*Ribeiroia metacercaria*)

41 spp. *Ribeiroia sp.* life cycle

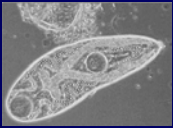


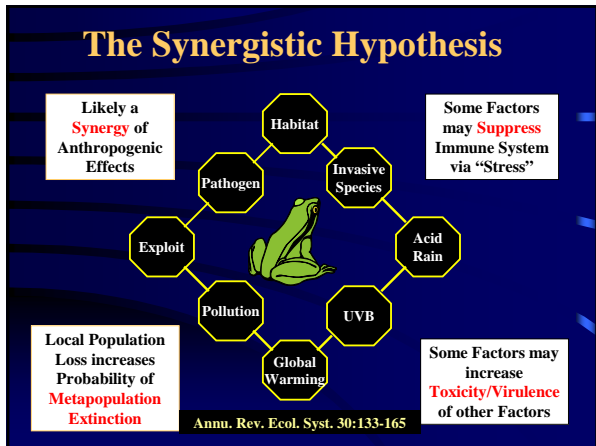
Science 284:802-804

Effects on Amphibians

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


➔ Survival/Reproduction





Amphibian Malformations

History of Amphibian Malformations




July 1996
175 Reports, 2/3 Counties in MN

Similar Reports emerged, especially in WI and Western States

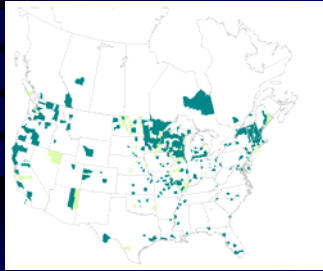
New County Middle School
LeSueur, MN
August 1995
Cindy Reinitz

Turn-road bordered by corn and soybean field

50% Deformed



Locations of Confirmed Malformations in North America



Brewster, Burleson, Liberty, and Harris

Hale, Crosby, Floyd, Castro

Gray & Smith: 1) 1999: 1.5% JUV; 3% AD
2) 2000: ??? (ca. 25% w/ TGSL)

Examination of Malformation Hypotheses



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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

No

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


Excess → Teratogen Methoprene IGH




Why not Retinoids?

- 1) Lack of geographic correlation
- 2) Exogenous RA have to be excessively high (30 mg/l, 2d)
- 3) Proximal-distal Duplication
- 4) Affects all organisms equally 
- 5) Affects limbs equally (hind)
- 6) Symmetrical Deformities 7) Bony Triangle



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





After Regenerative Decline

Eukaryotic Parasite Hypothesis



Trematodes

(Ribeiroia metacercaria)

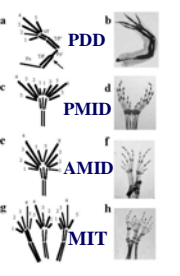


Why Trematodes?


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




Mechanical Inhibition



Predation/Cannibalism Hypothesis



Dave Pfennig

Animal Behaviour
46: 87-94

Regenerative Decline

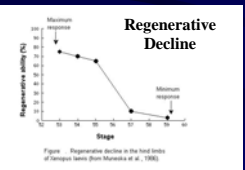


Figure - Regenerative decline in the hind limbs of *Xenopus laevis* (from Morimoto et al., 1985).

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
lainam@wimberley-tx.com



Amphibian Malformations

Report Malformations

Form: <http://www.npwrc.usgs.gov/narcam/>

Email: narcam@usgs.gov