Amphibian Malformations

An emerging dilemma with unsolved issues

Lecture Outline

- History of malformations
- Three main causes
- In depth detail of each cause
- Things that you can do to help
- References

Malformations in amphibians

Malformation History

- Earliest reports of frog abnormalities
  - 1700's
- Recently emerged in mid 1990's
  - Minnesota school children
  - Attempts to determine root of problem

Current data

- The Northern Prairie Wildlife Research Center
- 1,959 malformed frogs
- 54 species
- 44 states
- 4 Canadian provinces
- Northern leopard frog is most common
- Followed by Green frog and Bullfrog

Types of Malformations

Eye abnormalities

Incomplete tail resorption

Polymelia (Extra limbs)

Polydactyly (Extra digits)

Types of Malformations Cont.

Amelia (Missing limbs)

Ectromelia (Missing limb segments)

Ectrodactyly (Missing digits)

Other (abnormal skin webbing, bony triangles, etc.)

Most common characteristics

- Anurans are most commonly affected
- Multiple species are affected
- Most occur in hind limbs
- Usually involve deletions
- Multiple geographic regions
- Effects can be consistently observed

What causes malformations??

- Chemical Contaminants
- UV Radiation
- Parasitic Trematodes

Chemical Contaminants

- Agriculture chemicals (Roundup)
- Industrial pollutants (PCB's)

Chemical Contaminants

- Relatively few studies assessing chemical impacts
- Chemical contaminants don't just have lethal effects
- Amphibian limb defects - 69%
  - Ouellet et al. 1997

Chemical Contaminants

- Most pesticide-induced malformations involve hindlimbs
- WHY?
- Exposure differences

Chemical Contaminants

- Chemical contaminants may not be directly causing malformations
- Temp
- pH

Chemical summary

- Little work has been done
- Plenty of work left to do
- Some think that chemical comtaminants don't cause malformations
  - See Ankley et al. 2004
- Data is still inconclusive

UV Radiation

- UV-B
- 280-315nm
- Recent increase in radiation

UV-B Effects

- Cell death
- Slow growth rates
- Impair immune systems
- Various other sublethal effects
- Amphibians are at high risks
- Why would they be?

UV-B induced malformations

- Can occur at all life stages
- Early exposure can cause delayed effects

Sub-lethal effects

- Blistering
- Edema
- Scoliosis
- Retinal damage

Synergistic effects

- Developmental effects
- Decreased hatching success

Amphibian defenses to UV-B

- Habitat selection: dense forests, muddy water, deep water, crevices
- Egg-laying behavior (Marbled newt)
- Egg characteristics (Phyllomedusa spp.)
- Melanin

UV-B summary

- Malformations have been documented
- Can occur at all life stages
- Defenses have evolved
- More data is needed
  - Bridges and Boone 2003
- See PRIMENet website

Trematodes (*Ribeiroia ondatrae*)

Ribeiroia ondatrae

- Phylum – Platyhelminthes (flatworms)
- Class – Trematoda
- Order – Ribeiroida
- Family - Psilostomidae
- A.K.A. – flukes
- Flattened and oval in shape
- Two suckers

More general information

- The most visible and abundant parasites inhabiting N.A. anurans
- Numerous species have been documented inside amphibians
- Complex lifecycle
- Interesting fact – no anus

Trematode History

- 1st record linked to amphibian malformations – 1990
- Johnson et al. in 1999 confirmed trematodes causing malformations
- Present in preserved specimens – 1946
  - Loeffler et al. 2001
- Several other studies have been completed

How does this Cause this?

With this

Life cycle of Trematodes

Habitat types

- Drying pools
- Ephemeral ponds
- Permanent Ponds
- Large lakes

Means of spreading

- Wading birds

Factors increasing trematode infections

- Chemical contaminants
- Increased density
- Limited food resources
- Predator Locality

Trematode summary

- Definitely cause malformations
- Lots of data present
- Spread easily through various vectors
- Most important concern of amphibian malformations

Summary

- MORE DATA NEEDED
- Trematodes seem to be the most important vector of malformations
- A combination of multiple factors is usually present
- The presence of one or more of the above mentioned may increase malformations

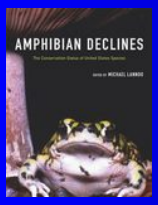
What you can do

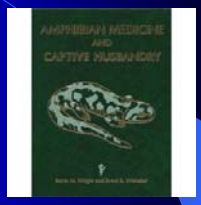
- Report any mass malformations to state or academic professionals
- Or report to the North American Reporting Center for Amphibian Malformations

Useful websites

- Northern Prairie Wildlife Research Center
  - http://www.npwrc.usgs.gov/
- PrimeNet (UV-B monitoring)
  - www.forestry.umt.edu/research/MFCES/programs/primenet/
- North American Reporting Center for Amphibian Malformations
  - http://frogweb.nbii.gov/narcam/
- Deformities in North American Amphibians
  - http://greenmuseum.org/c/vban/index.php

Reference books





Wildlife Diseases: Landscape Epidemiology, Spatial Distribution and Utilization of Remote Sensing Technology

Other references

Ankley, G. T., et al. 2004. Assessment if environmental stressors potentially responsible for malformations in North American anuran amphibians. Ecotoxicology and Environmental safety. 58:7-16.

Belden, L. K., 2006. Impacts of eutrophication on wood frog, *Rana sylvatica*, tadpoles infected with *Echinostoma trivolvis* cercariae. Canadian Journal of Zoology. 84:1315-1321.

Belden, L. K., and J. M. Kiesecker. 2005. glucocorticosteroid hormone treatment of larval tree frogs increases infection by *Alaria* sp. treamtode cercariae. Journal of Parasitology. 91(3):686-688.

Blaustein, A. R., and L. K. Belden. 2003. Amphibian defenses against ultraviolet-B radiation. Evolution and Development. 5(1):89-97.

Blaustein, A. R., J. M. Rmansic, and E. A. Scheesele. 2005. Ambient levels of ultraviolet-B radiation cause mortality in juvenile western toads, *Bufo boreas*. American Midland Naturalist. 154:375-382.

Bridges, C. M., and M. D. Boone. 2003. The interactive effects of UV-B and insecticide exposure on tadpole survival, growth and development. Biological Conservation. 113:49-54.

Calfee, R. D., C. M. Bridges, and E. E. Little. 2006. Sensitivity of two salamander (*Ambystoma*) species to ultraviolet radiation. Journal of Herpetology. 40(1):35-42.

Esch, G. W., M. A. Barger, and K. J. Fellis. 2002. The transmission of digenetic trematodes: style, elegance, complexity. Integrative and Comparative Biology. 42:304-312.

Gillilland III, M. G., and P. M. Muzzall. 2002. Amphibians, trematodes, and deformities: an overview from southern Michigan. Comparative Parasitology. 69(1):81-85.

Johnson, P. T. J., et al. 2002. Parasite (*Ribeiroia ondatrae*) infection linked to amphibian malformations in the western United States. Ecological Society of America. 72(2):151-168.

Johnson, P. T. J., et al. 2003. Limb deformities as an emerging parasitic disease in amphibians: Evidence from museum specimens and resurvey data. Conservation Biology. 17(6):1724-1737.

Johnson, P. T., and J. M. Chase. 2004. Parasites in the food web: linking amphibian malformations and aquatic eutrophication. Ecology Letters. 7:521-526.

More references

Kiesecker, J. M. 2002. Synergism between trematode infection and pesticide exposure: a link to amphibian limb deformities in nature? Proceedings of the National Academy of Sciences. 99(15):9900-9904.

Koprivnikar, J., R. L. Baker, and M. R. Forbes. 2006. Environmental factors influencing trematode prevalence in grey treefrog (*Hyla versicolor*) tadpoles in southern Ontario. Journal of Parasitology. 92(5):997-1001.

Lefebvre, F., and R. Poulin. 2005. Progenesis in digenean trematodes: a taxonomic and synthetic overview of species reproducing in their second intermediate hosts. Parasitology. 130:587-605.

Loeffler, I. K., et al. 2001. Leaping lopsided: a review of the current hypothesis regarding etiologies of limb malformations in frogs. The Anatomical Record 265:228-245.

Ouellet, M., et al. 1997. Hindlimb deformities (Ectromelia, Ectrodactyly) in free-living anurans from agricultural habitats. Journal of Wildlife Diseases. 33(1):95-104.

Palen, W. J., et al. 2005. Impact of UV-B exposure on amphibian embryos: linking species physiology and oviposition behaviour. Proceedings of the Royal Society B. 272:1227-1234.

Peterson, G. S., et al. 2002. Assessment of the risk of solar ultraviolet radiation to amphibians. II. In situ characterization of exposure in amphibian habitats. Environmental Science and Technology. 36:2859-2865.

Relyea, R., and J. Hoverman. 2006. Assessing the ecology in ecotoxicology: a review and synthesis in freshwater systems. Ecology Letters. 9:1157-1171.

Schotthoefer, A. M., et al. 2003. Influences of *Ribeiroia ondatrae* (Trematoda: Digenea) infection on limb development and survival of northern leopard frogs (*Rana pallustris*): effects of host stage and parasite-exposure level. Canadian Journal of Zoology. 81:1144-1153.

Stopper, G. F., et al. 2002. How trematodes cause limb deformities in amphibians. Journal of Experimental Zoology. 294:252-263.

Taylor, C. N., K. L. Oseen, and R. J. Wasserug. 2004. On the behavioral response of *Rana* and *Bufo* tadpoles to echinostomatoid cercariae: implications to synergistic factors influencing trematode infections in anurans. Canadian Journal of Zoology. 82:701-706.

Trenham, P. C., and S. A. Diamond. 2005. Coordinated studies of ultraviolet radiation and amphibians in lentic wetland habitats. Ecosystems. 8:455-461.

Questions?