AMPHIBIANS AS MONITORS OF ECOSYSTEM HEALTH

Kimberlee B. Beckmen, MS, DVM, PhD,[1]* Camilla L. Lieske, DVM, MPVM,[1] Joseph E. Murphy, MS, [1]Anna Schotthoefer, MS,[1] Lucinda B. Johnson, PhD,[2] Catherine M. Johnson, PhD,[2] Rebecca Cole, PhD,[3] and Val R. Beasley, DVM, PhD[1]

[1]College of Veterinary Medicine, University of Illinois, Urbana-Champaign, 2001 South Lincoln Avenue, Urbana IL 61802 USA; [2]Natural Resources Research Institute, University of Minnesota, 5013 Miller Trunk Hwy, Duluth MN 55811 USA; [3]National Wildlife Health Center, 6006 Schroeder Road, Madison WI 53711 USA

Abstract

Amphibians have often been described as sentinels of environmental damage on many scales. On a worldwide scale, many populations of amphibians have experienced marked declines. Many potential causes of these declines have been suggested including:

- habitat degradation, fragmentation, and destruction;
- increased UV irradiation due to ozone thinning;
- global climate change;
- introductions of exotic species;
- infectious diseases such as chytridiomycosis, *Ranavirus* infections, and severe parasitism;
- anthropogenic chemicals such as pesticides, acid-rain, endocrine disruptors, and others.

Because amphibian populations, community structure, and health are influenced by environmental factors that operate on multiple spatial scales, identification of the inciting cause for every population decline is impossible. In particular, anuran amphibians living within damaged ecosystems may be at increased risks of decreased reproductive success, or increased direct mortality due to stress, water quality problems, toxicoses, infectious diseases, and predation.

Our research group has recently demonstrated that herbicide exposure in microcosms or mesocosms reduces size at metamorphosis, causes hypoxia, and may accelerate predation.[4] Additionally, in our field studies, macroinvertebrate richness and anuran species richness were negatively correlated with increased agricultural uses of land. High edge contrasts decreased habitat value for selected species of anurans. However, woodlands near agricultural land seemed to increase habitat value to amphibians, as they were associated with increased populations of some anuran species.[5]

Adult cricket frogs (*Acris crepitans*) in the upper Midwest during breeding season, and recent metamorphs in late summer, were consistently found in areas where there was a gentle slope into the water; and greater numbers were present when aquatic macrophytes were abundant. In the same study, herbicide-induced damage to macrophytes was associated with increased intensities of echinostome infections, a trematode larvae that encysts in renal tissue.[1] Others have described malformations (including missing or supernumerary limbs), and increased death losses, as a

consequence of larval trematode (*Ribeiroia* sp.) infections in laboratory and field studies. Although northern leopard frogs (*Rana pipiens)* at our study sites had a malformation rate of about 1.2 % over 3 yr (3,188 frogs examined in the field), and four ponds had a prevalence of *Ribeiroia* sp. from 6.3-100%, none of malformed frogs examined was found to be infected with *Ribeiroia* sp. metacercariae. We are currently investigating factors potentially related to the prevalence and intensity of trematode infections in frogs.

In another study of Illinois cricket frogs, coplanar polychlorinated biphenyls and polychlorinated dibenzo-furans at three out of three sites had high numbers of juvenile males relative to females (ratio of males to females was 2:1). While at three of three control sites, the male female sex ratio was consistent with historic reports (1:2) suggesting endocrine disruption.[8] Also, our laboratory group recently examined historic specimens of Illinois cricket frogs from museums across the United States, and demonstrated a rate of intersex gonads of approximately 2.5% from 1850-1929, 15.5% from 1930-1942, 16.5% from 1946-1959 and 11% from 1960-1979. Intersex gonads were found in about 3% of cricket frogs collected in Illinois by our group in the 1990s. The greatest percentage of intersex individuals was in the northeastern region of the state. We are currently investigating the possible contributions of environmental contaminants, or weather, to the dramatic increase in the percentage of individuals with ovotestes from the 1930s to the end of the 1950s.

Chytridiomycosis has been implicated in mass die-offs of population of montane anurans in several regions, including the western United States, Panama, and Australia.[2,3,6] Although the fungal organism *Batrachochytrium dendrobatidis* has been demonstrated to be highly lethal in captive as well as field situations, this fungus has been observed in the skin of some species of Midwestern anurans, including Illinois cricket frogs, for several years and it is not always associated with apparent die-offs.[7]

Our research group is endeavoring to determine habitat characteristics that maximize "healthy" outcomes for amphibians. By identifying the characteristics of healthy and unhealthy ecosystems that give rise to diverse amphibian communities, we expect to be able to offer recommendations for habitat restoration programs to help maintain healthier and more abundant frog populations.

ACKNOWLEDGMENTS

We gratefully acknowledge the additional contributions of Carl Richards, Pat Schoff, Marv Piwoni, Tony Treml, and Anson Koehler.

DISCLAIMER

Although some of the research described has been funded in part by the U.S. Environmental Protection Agency's STAR program through grant # R 825867, it has not been subjected to any EPA review and therefore does not necessarily reflect the views of the Agency, and no official endorsement should be inferred.

LITERATURE CITED

1. Beasley, V. R., S. A. Faeh, B. Wikoff, J. Eisold, D. Nichols, R. Cole, A. M. Schotthoefer, C. Staehle, M. Greenwell, and L. E. Brown. 2001. Risk factors and the decline of the cricket frog, *Acris crepitans*: Evidence for involvement

of herbicides, parasitism, and habitat modification. *In*: Lannoo MJ (ed). Status and Conservation of North American Amphibians. University of California Press, Berkeley CA. In press.
2. Berger, L., R. Speare, P. Daszak, D. E. Green, A. A. Cunningham, C. L. Goggin, R. Slocombe, M. A. Ragan, A. D. Hyatt, K.R. McDonald, H. B. Hines, K. R. Lips, G. Marantelli, and H. Parkes. 1998. Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. Proc. Nat. Acad. Sci. USA 95:9031-9036.
3. Daszak, P., L. Berger, A.A. Cunningham, A.D. Hyatt, D.E. Green, R. Speare. 1999. Emerging infectious diseases of amphibian population declines. Emerg. Infect. Dis. 5:735-748.
4. Diana, S.G., W. J. Resetarits, D. J. Schaeffer, K. B. Beckmen, and V. R. Beasley. 2000. Effects of atrazine on amphibian growth and survival in artificial aquatic communities. Environ. Toxicol. Chem. 19:2961-2967.
5. Johnson, C. M., L. B. Johnson, C. Richards, and V. R. Beasley. 2001. Predicting the occurrence of amphibians: An assessment of multiple-scale models. *In*: Scott, J. M., P. J. Heglund, M. Morrison, M. Raphael, J. Haufler, and B. Wall (eds). Predicting Species Occurrences: Issues of Scale and Accuracy. Island Press, Covello CA. In press.
6. Lips, K. R., and K. J. McGraw. 1999. Mass mortality and population declines of anurans at an upland site in Western Panama. Conserv. Biol. 13:117-125.
7. Pessier, A. P., D. K. Nichols, J. E. Longcore, and M. S. Fuller. 1999. Cutaneous chytridiomycosis in poison dart frogs (*Dendrobates* spp.) and White's tree frog (*Litoria caerulea*). J. Vet. Diagn. Invest. 11:194-199.
8. Reeder, A. L., G. L. Foley, D. K. Nichols, L. G. Hansen, B. Wikoff, S. Faeh, J. Eisold, M .B. Wheeler, R. Warner, J. E. Murphy, and V. R. Beasley. 1998. Forms and prevalence of intersexuality and effects of environmental contaminants on sexuality in cricket frogs (*Acris crepitans*). Environ. Health Perspect. 106:261-266.