



LOCAL AND LANDSCAPE HABITAT ASSOCIATION, POPULATION ECOLOGY AND FUTURE RECOVERY OF CRAWFISH FROGS (*RANA AREOLATA*) IN INDIANA



Male crawfish frog in a breeding wetland. Note distended vocal sacs.

Current Status

Fourth year of three-and-a-half year project plus one-year extension

Funding Sources and Partners

State Wildlife Grant, Indiana University

Project Personnel

Dr. Michael Lannoo, Indiana University School of Medicine

Dr. Daryl Karns, Hanover College (deceased)

Dr. Joe Robb, U.S. Fish & Wildlife Service, Big Oaks National Wildlife Refuge

Dr. John Whitaker, Indiana State University

Dr. John Crawford, Lindenwood College, served on the project from Jan. 1–June 30, 2009

Perry Williams, U.S. Fish & Wildlife Service, Big Oaks National Wildlife Refuge

Ben Walker, U.S. Fish & Wildlife Service, Big Oaks National Wildlife Refuge

Nate Engbrecht, Indiana State University, graduate student

Jennifer Heemeyer, Indiana State University, graduate student

Vanessa Kinney, Indiana State University, graduate student

Andrew Hoffman, Big Oaks National Wildlife Refuge, refuge intern

Todd Gerardot, Big Oaks National Wildlife Refuge, refuge intern

Dr. Alan Pessier, San Diego Zoo, veterinarian (disease)

Dr. Irene Macallister, U.S. Army Corps of Engineers (disease)

Dr. Stephen Richter, Eastern Kentucky University (genetics)
Emily Gustin, Eastern Kentucky University (genetics)
Dr. Alisa Gallant, U.S. Geological Survey EROS Data Center (GIS)

Dr. Robert Klaver, U.S. Geological Survey EROS Data Center (ecological modeling)

Bill Peterman, consultant, served on the project from Jan. 1–June 30, 2009

Tess Piening, Big Oaks National Wildlife Refuge, refuge intern

Stephanie Bishir, Big Oaks National Wildlife Refuge, refuge intern

David Pananu, Big Oaks National Wildlife Refuge, refuge intern

Abby Burns, Big Oaks National Wildlife Refuge, refuge intern

Alex Robinson, part-time technician

John Ryan, part-time technician

Shane Stephens, part-time technician

Austin McClain, part-time technician

B. Jagger Foster, part-time technician

Taenia Wheat, part-time technician

Austin May, part-time technician

Susan Lannoo, consultant (unpaid)

Peter Lannoo, graphics designer (unpaid)

Background and Objectives

Crawfish frogs are large (adults are 3 inches or longer), heavy frogs that spend much of their adult life in crayfish burrows. In Indiana, crawfish frogs (*Lithobates [Rana] areolatus*) are considered State Endangered, and their declining status across much of their range has caused broad concern about their conservation. According to Sherman Minton, crawfish frogs were locally plentiful in southwestern Indiana until about 1970. The reasons for their recent and rapid decline are unknown.

Typically, crawfish frogs are associated with tallgrass prairies or other native grasslands; however, these habitats are increasingly being fragmented by, or converted to, row-crop agriculture. Crawfish frogs are also considered weak larval competitors, which likely results in reduced recruitment into populations. Local and regional declines may be further enhanced by interactions with exotic species and the emergence of infectious diseases. While there is some information on general habitat use and population demographics, the fossorial nature and scarcity of crawfish frogs has made detailed investigations difficult and recovery plans ineffective.

If the ultimate goal for an endangered species is the recovery of populations, then distribution, habitat use and mechanisms of decline must be investigated. The status of the crawfish frog in Indiana presents a unique opportunity for this type of study.

Objectives

1. Determine the status of crawfish frog populations in Indiana.

2. Develop methods to monitor the status of crawfish frog populations in Indiana.

3. Determine population parameters of crawfish frogs on public lands in an effort to delimit potential life-history bottlenecks that affect the survival of this species.

4. Define natural history features such as movement patterns (across the landscape), activity patterns (daily and seasonally) and habitat-use features (burrow location) of crawfish frogs, and identify threats to this species from current landscape attributes (roads, agricultural fields) and land-use practices (frequency of plowing, prescribed burning).

5. Determine the genetic relationships among Indiana crawfish frog populations.

6. Define the role of disease (chytrid fungus) in limiting Indiana crawfish frog populations.

7. Determine how practical captive rearing can be for augmenting populations.

8. Run parallel studies at sites in southwest Indiana (Hillenbrand Fish & Wildlife Area, Dave's Pond) and southeast Indiana (Big Oaks National Wildlife Refuge).

9. Provide management recommendations to Indiana DNR and U.S. Fish & Wildlife Service to maximize the likelihood that crawfish frog populations persist in Indiana.

Methods

We use a wide variety of methods and techniques, including drift fences/pitfall traps, call surveys, seining, minnow trapping, radio telemetry, museum and literature searches, wildlife cameras, song meters, digital videography, pit tagging, toe clipping, microsatellite arrays, histology, PCR analyses, visual surveys, disease surveys, tissue sampling for genetic analysis, and captive rearing, as follows:

1) Status: Literature searches, museum searches, call surveys, seining, minnow trapping, song meters

2) Monitoring: Occupancy modeling, song meters, minnow trapping, egg mass counts

3) Population parameters: Drift fences/pitfall traps, radio telemetry, pit tagging, histology

4) Natural history: Drift fences/pitfall traps, radio telemetry, wildlife cameras, videography

5) Genetics: Toe clipping, microsatellite arrays

6) Disease: Swabs for chytrid fungus, histology, PCR

7) Population augmentation: Captive rearing pools, diet, timing

8) Statewide comparison: Two crews, one in southwest Indiana led by Lannoo, the other at Big Oaks led by Karns and Robb

Progress

Papers submitted:

Engbrecht, N.J., P.J. Williams, J.R. Robb, D.R. Karns, M.J. Lodato, T.A. Gerardot and M.J. Lannoo. Is there hope for the Hoosier Frog? An update on the status of crawfish frogs in Indiana, with recommendations for their conservation. Proceedings of the Indiana Academy of Science.

Kinney, V.C., J. Maerz and M.J. Lannoo. Adult survivorship, juvenile recruitment, and juvenile fitness metrics in crawfish frogs (*Lithobates areolatus*), a cryptic, “near-threatened” species. *Journal of Wildlife Management*.

Papers in press:

Nunziata, S.O., M.J. Lannoo, J.R. Robb, D.R. Karns, S.L. Lance, and S.C. Richter. Population and conservation genetics of crawfish frogs, *Lithobates areolatus*, at their Northeastern range limit. *Journal of Herpetology*, In Press.

Williams, P.J., J. R. Robb, and D. R. Karns. (in Press). Habitat selection by crawfish frogs (*Lithobates areolatus*) in a large mixed grassland/forest habitat. *J. Herpetol.*

Papers published:

Engbrecht, N.J. and J.L. Heemeyer. 2010. *Lithobates areolatus circulosus* (northern crawfish frog). *Heterodon platyrhinos* (eastern hog-nosed snake). Predation. *Herpetological Review* 41:197.

Engbrecht, N.J. and J.L. Heemeyer and M.J. Lannoo. 2012. *Lithobates areolatus circulosus* (Northern Crawfish Frog). *Coluber constrictor* (Black Racer). Thwarted Predation. *Herpetological Review* 43:323–324.

Engbrecht, N. J. and M.J. Lannoo. 2010. A review of the status and distribution of crawfish frogs (*Lithobates areolatus*) in Indiana. *Proceedings of the Indiana Academy of Sciences* 119:64–73.

Engbrecht, N.J., S.J. Lannoo, J.O. Whitaker and M.J. Lannoo. 2011. Comparative morphometrics in ranid frogs (subgenus *Nenirana*): Are apomorphic elongation and a blunt snout responses to deep, small-bore burrow dwelling in crawfish Frogs (*Lithobates areolatus*) *Copeia* 2011:285–295.

Engbrecht, N.J. and M.J. Lannoo. 2012. Crawfish Frog behavioral differences in postburned and vegetated grasslands. *Fire Ecology* 8:63–76.

Heemeyer, J.L., V.C. Kinney, N.J. Engbrecht, and M. J. Lannoo. 2010. The biology of crawfish frogs (*Lithobates areolatus*) prevents the full use of telemetry and drift fence techniques. *Herpetological Review*. 41:42–45.

Heemeyer, J.L. and M.J. Lannoo. 2010. A new technique for capturing burrow-dwelling anurans. *Herpetological Review* 41:168–170.

Heemeyer, J.L. and M.J. Lannoo. 2011. *Lithobates areolatus circulosus* (northern crawfish frog). Winterkill. *Herpetological Review* 42:261–262.

Heemeyer, J.L. and M.J. Lannoo. 2012. Breeding migrations in crawfish frogs (*Lithobates areolatus*): Long-distance movements, burrow philopatry, and mortality in a near-threatened species. *Copeia* 2012:440–450.

Heemeyer, J.L., P.J. Williams and M.J. Lannoo. 2012. Obligate crayfish burrow use and core habitat requirements of Crawfish Frogs. *Journal of Wildlife Management* 76:1081–1091.

Hoffman, A.S., J.L. Heemeyer, P.J. Williams, J.R. Robb, D.R. Karns, V.C. Kinney, N.J. Engbrecht, and M.J. Lannoo. 2010. Strong site fidelity and a variety of imaging techniques reveal around-the-clock and extended activity patterns in crawfish frogs (*Lithobates areolatus*). *Bioscience* 60:829–834.

Kinney, V.C., N.J. Engbrecht, J.L. Heemeyer, and M.J. Lannoo. 2010. New county records for amphibians and reptiles in southwest Indiana. *Herpetological Review* 41:387.

Kinney, V.C., J.L. Heemeyer, A.P. Pessier, and M.L. Lannoo. 2011. Seasonal pattern of *Batrachochytrium dendrobatidis* infection and mortality in *Lithobates areolatus*: Affirmation of Vredenburg’s “10,000 Zoospore Rule” *PLoS One* 6(3): e16708. doi:10.1371/journal.pone.0016708.

Kinney, V.C. and M.J. Lannoo. 2010. *Lithobates areolatus circulosus* (northern crawfish frog). Breeding. *Herpetological Review* 41:197–198.

Lannoo, M.J., V.C. Kinney, J.L. Heemeyer, N.J. Engbrecht, A.L. Gallant, and R.W. Klaver. 2009. Mine spoil prairies expand critical habitat for endangered and threatened amphibian and reptile species. *Diversity* 1:118–132.

Williams, P.J., J.R. Robb, R.H. Kappler, T.E. Piening, and D.R. Karns. 2012. Intraspecific density dependence in larval development of the crawfish frog *Lithobates areolatus*. *Herpetological Review* 43:36–38.

Williams, P.J., J. R. Robb, and D. R. Karns. 2012. Occupancy modeling of breeding crawfish frogs in southeastern Indiana. *Wildl. Society Bull.* 36:350-357.

Theses:

Engbrecht, N.J. 2010. The Status of Crawfish Frogs (*Lithobates areolatus*) in Indiana, and a Tool to Assess Populations. M.S. Thesis, Indiana State University, Terre Haute, IN.

Heemeyer, J.L. 2011. Breeding Migrations, Survivorship, and Obligate Crawfish Burrow Use by Adult Crawfish Frogs (*Lithobates areolatus*). M.S. Thesis, Indiana State University, Terre Haute, IN.

Kinney, V.C. 2011. Adult Survivorship and Juvenile Recruitment in Populations of Crawfish Frogs (*Lithobates areolatus*), with Additional Consideration of the Population Sizes of associated Pond Breeding Species. M.S. Thesis, Indiana State University, Terre Haute, IN.

Presentations:

Lannoo, M.J. Habitats lost and habitats found. Association of Zoos and Aquariums Workshop (Keynote). Toledo Zoo, April ‘09.

Lannoo, M.J. The Biology of Crawfish Frogs. Association of Zoos and Aquariums Workshop (Keynote). April ‘10.

Lannoo, M.J. The Conservation Biology of Crawfish Frogs. Iowa Lakeside Lab, June ‘10.

Lannoo, M.J. The Conservation Biology of Crawfish Frogs. Hoosier Herp Society, September ‘10.

Lannoo, M.J. Update on the Biology of Crawfish Frogs. Association of Zoos and Aquariums Workshop (Keynote). April ‘11.

Lannoo, M.J. The Conservation Biology of Crawfish Frogs. SE PARC February '11.

Lannoo, M.J. Update on the Conservation Biology of Crawfish Frogs. Iowa Lakeside Lab, June '11.

Lannoo, M.J. The Biology of Crawfish Frogs. Canadian Association of Herpetologists' Annual Meeting (Keynote), October '11.

Lannoo, M.J. Update on the Conservation Biology of Crawfish Frogs. Iowa Lakeside Lab, June '12.

Lannoo, M.J. Ethics and values across changed and changing landscapes. World Congress of Herpetology (Invited), August '12.

Lannoo, M.J. The Conservation Biology of Crawfish Frogs. University of Iowa, September '12.

Lannoo, M.J. Can We Re-Introduce Crawfish Frogs Into Iowa. Iowa State University, September '12.

Engbrecht, N.J. Status and Distribution of Crawfish Frogs (*Lithobates areolatus*) in Indiana. Indiana Academy of Science, October '09.

Engbrecht, N.J., V.C. Kinney and M.J. Lannoo. Using call counts to estimate anuran population sizes: an example using Crawfish Frogs (*Lithobates areolatus*). SE PARC, February '11.

Engbrecht, N.J. and M.J. Lannoo. Status and conservation of Crawfish frogs in Indiana. SE PARC, February '11.

Heemeyer, J.L. Post-breeding Migration and Habitat Selection of the Crawfish Frog (*Lithobates areolatus*). Indiana Academy of Science, October '09.

Heemeyer, J.L. and M.J. Lannoo. Crawfish Frog migratory behavior and survival. SE PARC, February '11.

Hoffman, A.S., P.J. Williams, J.R. Robb, and Daryl R. Karns. Activity Patterns of the Crawfish Frog (*Lithobates [Rana] areolatus*) at Crayfish Burrows in Big Oaks National Wildlife Refuge, Southeastern Indiana. Indiana Academy of Science, October '09.

Kinney, V.C. Breeding Biology of Crawfish Frogs (*Lithobates areolatus*) in Southwestern Indiana. Indiana Academy of Science. October '09.

Kinney, V.C., J.L. Heemeyer, A.P. Pessier, and M.L. Lannoo. Seasonal pattern of *Batrachochytrium dendrobatidis* infection and mortality in *Lithobates areolatus*: Affirmation of Vredenburg's "10,000 Zoospore Rule" SE PARC February '11.

Williams, P.J., A.S. Hoffman, J.R. Robb, and D.R. Karns. Burrow Selection by the Crawfish Frog (*Lithobates [Rana] areolatus*) in Southeastern Indiana. Indiana Academy of Science, October '09.

Narrative:

We have made substantial progress in understanding the life history and natural history features of crawfish frogs in Indiana.

We understand much of their historic distribution and their current distribution, not only in Indiana but also throughout other states east of the Mississippi River. We understand when they breed and have identified a large percentage, perhaps all, of their known breeding sites in Indiana. We understand survivorship in egg, larval,

and juvenile life history stages, as well as in postbreeding adults. We sent water samples of breeding wetlands for analyses and have shown that neither pesticides nor metals are factors influencing survivorship.

We have successfully reared large numbers of tadpoles to metamorphosis. We have now tracked crawfish frogs for nearly 9,000 "telemetered frog days," from these data understand where adult burrows are located, and have made a distinction between primary and secondary burrows. We understand activity patterns and habitat use.

We now understand the pattern of infection by the chytrid fungus (*Batrachochytrium dendrobatidis*), which exhibits seasonal waxing and waning, and kills less than 7 percent of adults during or immediately after breeding.

We have developed a technique for estimating crawfish frog population size based on call characteristics. There are likely fewer than 700 crawfish frog adults in Indiana, a figure that confirms their endangered status in the state.

Trying to radiotrack juveniles has been a challenge, but after a major push in 2011 we understand that juvenile dispersion mimics adult post-breeding migrations—juveniles move away from wetlands in a straight line, apparently until they intersect a suitable burrow.

We better understand the role that management techniques such as prescribed burning, cultivation, mowing and establishing food plots have on populations. Genetic analyses have been done and will soon be published. These data show that individual breeding sites at Hillenbrand FWA are genetically distinct from those at Big Oaks NWR.

We use the data collected from drift fences at Nate's Pond and Cattail Pond from 2009–2012 on adult and juvenile survivorship to calculate population trajectories. Stage-based matrix models show that Cattail Pond is a population sink, while during two years (2009, 2012) Nate's Pond was also acting as a sink. During 2010 and 2011, Nate's Pond demonstrated positive population growth, but overall numbers for the four years of this study show that Nate's Pond also was exhibiting negative population growth. In short, adult longevity is not keeping pace with larval mortality, and both populations were being augmented by recruitment from Big Pond. While adult inter-annual survivorship was 31.6 percent from 2009–2010 and 30.6 percent from 2010–2011, after strip disking, survivorship was nearly halved to 15.7 percent in 2011–2012. Drs. Lannoo and Robb have assembled a Crawfish Frog Recovery Plan for Indiana, and submitted it to DNR biologists in 2012.

Workers within the state communicate frequently. In addition we have set up a listserve (sevosa@listserve.eku.edu) to communicate with people working on this species group (three species: crawfish frogs, gopher frogs [*L. capito*], and dusky gopher frogs [*L. sevosus*, which are federally endangered]).

Cost: \$820,518, Extension: \$50,048