

## EFFECTIVE UNDERGRADUATE-BASED HERPETOLOGICAL RESEARCH IN AN URBAN ENVIRONMENT

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*Abstract* — We describe a successful undergraduate-based herpetological research laboratory situated in an urbanized area at Davidson College in Davidson, North Carolina. Due to the various threats posed to herpetofauna in urban areas, many unique research opportunities exist for undergraduate students. Strategies that we have found to aid in the success of undergraduate research include using technology to facilitate research, focusing on ecosystems in which students may have had previous class work, establishing long-term projects, collaborating with outside organizations, and involving the local community in our research program. Conducting research with undergraduate students does present challenges; however they can generally be overcome by close mentoring and developing strong working relationships with everyone involved. Overall, undergraduate students can serve as highly productive researchers to investigate threats to reptiles and amphibians in urban environments.

*Key Words* — Davidson College, Education, Research Strategies, Undergraduate Students

Many regions of the eastern United States are experiencing drastic and unprecedented changes in land cover and land use (Griffith et al. 2003). These changes typically consist of a transition from more natural or rural landscapes to environments dominated by heavy urbanization. Unlike other land-uses that may provide opportunities for habitats to recover, such as certain forestry practices, urbanization represents a permanent change in land cover, at least for our foreseeable future (Wilcove et al. 2000). Native animals inhabiting areas that have undergone urbanization are generally negatively impacted due to a variety of factors including habitat loss, road mortality, pollution, and the introduction of non-native species (McKinney 2002). Most herpetologists have historically sought “pristine” or at least more natural environments in which to conduct their research. Such research provides valuable insight into a species’ biology in natural situations and can serve as a baseline for comparisons of studies in altered environments. Urbanized areas are quickly becoming a dominant land form in many parts of the world. Thus, it is imperative that we study animals in natural and urbanized areas to better understand how some species persist in urbanized areas and to better mediate the

negative impacts human activities have on other species.

Historically, most ecological research with an emphasis on conservation has been conducted by large institutions, especially universities. These institutions typically have the infrastructure, personnel, and other resources that make it possible to conduct large-scale ecological and conservation-focused studies. In general, faculty at large institutions are expected to have strong research programs and graduate students and postdoctoral fellows provide a motivated and highly productive workforce. Despite these generalities, the U.S. federal government (e.g., National Science Foundation), the Association of Southeastern Biologists, and many other organizations have placed emphasis on the involvement of undergraduate students in research. Involvement of undergraduates in meaningful research, especially early in their undergraduate careers, greatly increases the probability that they will attend graduate school and eventually become successful scientists (Nagda et al. 1998). However, because many of the research responsibilities at large institutions are shouldered by graduate students and postdoctoral fellows, undergraduates often are relegated to “technician” roles and do not have an opportunity to be the

principal investigators on their own research projects. Therefore, undergraduate institutions that place a strong emphasis on research may offer in many cases greater opportunities for undergraduates to participate in a meaningful way in significant ecological and conservation-focused research.

Our goal is to describe how urbanized environments offer unique opportunities for the development of effective, undergraduate-based research, outreach, and conservation initiatives focusing on amphibians and reptiles. Specifically, we will: 1) describe how we have developed a productive herpetological research laboratory at an undergraduate institution, 2) explain how urban environments offer unique opportunities for developing research projects for undergraduate students, and 3) discuss strategies we have used to effectively involve undergraduate students in herpetological research.

#### HERPETOLOGY AT DAVIDSON COLLEGE

Davidson College is a highly selective independent liberal arts college with 1,700 undergraduate students and is located approximately 30 km N of Charlotte, North Carolina, USA. The emphasis on undergraduate research is strong in the Biology Department at the college. All 12 tenure-track faculty are expected to develop programs based on undergraduate research. Faculty in the Biology Department have been successful in obtaining funding to support these programs. In 2004 for example, Davidson Biology faculty were awarded collectively over 3 million U.S. dollars in funding to support programs based on undergraduate student research and the Biology Department has been awarded three National Science Foundation Early Career Development awards.

Since 1998, the Davidson College Herpetology Laboratory (DCHL) has been successful in developing an effective undergraduate-based research program. However, herpetology at Davidson College is not new. From 1939 to 1973, Elmer E. Brown was a herpetologist who taught and conducted research at Davidson College. Brown made significant herpetological collections of the region, most of which are deposited at the North Carolina Museum of Natural Sciences in Raleigh, NC. Brown also kept meticulous field notes and published several papers on the reptiles and amphibians of the region (Brown 1979, 1992). These field notes, collections, and publications have been extremely valuable to members of the current DCHL because they provide a foundation on which other research can be developed (Rice et al. 2001).

Davidson College is located at the northern edge of what is considered the "Charlotte-Metro Area" in Mecklenburg County, NC. The area has a rich diversity of amphibians and reptiles - 27 amphibians and 38 reptiles have been recorded from Mecklenburg County. Despite the high levels of urbanization, substantial populations of most of these species can still be found in many areas (Rice et al. 2001). The Charlotte-Metro area has experienced rapid urban growth over the last few decades and all indications are that urbanization will continue for the foreseeable future. Studies show that approxi-

mately 16 ha of land are converted to urban land cover each day in the Charlotte-Metro area (Catawba Lands Conservancy unpubl. data). The Charlotte Metro area is projected to grow by 53% and lose 35% of its remaining natural lands to development between 2005 and 2030 (Ewing et al. 2005). Although this results in a decrease in natural amphibian and reptile populations in the region, such high levels of urbanization offer unique opportunities for the development of wide-range research projects suitable for undergraduate students.

#### ADVANTAGES OF AN URBAN LANDSCAPE FOR UNDERGRADUATE HERPETOLOGICAL RESEARCH

We have found that herpetology, as a taxonomically-defined field of study, cuts across many disciplines of biology thus providing numerous opportunities for the development of unique and interesting research projects suitable for undergraduate research students. Additionally, we have found that the urban environment represents an ideal setting in which to develop undergraduate-based research projects focusing on reptile and amphibian populations. Threats to urban-inhabiting reptiles and amphibians are diverse. We have found undergraduate students to be capable of tackling diverse conservation-related issues. Strategies that we have found to aid in the success of undergraduate research include: 1) using technology to facilitate research, 2) focusing on ecosystems in which students may have had previous class work, 3) establishing long-term projects, 4) collaborating with outside organizations, and 5) involving the community in our research program.

Use of technology increases the number and type of projects that can be conducted by undergraduate students. Many undergraduate students are familiar with and skillful at using technology, especially computers, and capable of incorporating their computing knowledge into herpetological research. We have found technology-savvy students often excel at landscape-scale studies that employ geographic information systems (GIS). From a landscape perspective, urban and suburban environments are extremely heterogeneous, especially areas undergoing rapid urban sprawl. Patches of forests, prairies and wetlands are often found in close proximity to residential areas. In areas of high human population density (i.e., urban centers), nature preserves and city parks may be the only habitats available. This heterogeneity creates gradients of habitat disturbance. Understanding patterns of species distribution and/or abundance in relation to habitat disturbance is essential for reptile and amphibian conservation. Students of the DCHL have investigated relationships between habitat disturbance and stream salamander abundance (Willson and Dorcas 2003) and distribution of Eastern Box Turtles (*Terrapene carolina*) (Budischak et al. 2006) and anurans (Googh et al. 2006). We have found that undergraduate students are able to effectively examine the consequences of landscape-scale disturbance on reptiles and amphibians using GIS.

Another technology successfully employed by our undergraduate students is radiotelemetry. Radiotelemetry not only

allows students to gain valuable field experience when locating animals, but it also permits the use of GIS, global positioning systems (GPS) and other technologies to investigate habitat use, home range, site fidelity and other aspects of the animal's natural history. Information gathered from urban areas on animal movements is particularly valuable to conservation biologists. In particular, radiotelemetry studies provide insight on why some species persist in landscapes bisected by roads, railroads, and other barriers, whereas other species disappear. Recent DCHL radiotelemetry studies of Eastern Rat Snakes (*Elaphe [obsoleta] alleghaniensis*) showed that their persistence in urban areas may be the result of their preferred use of edge habitat (Hill et al. unpubl. data; Johnson et al. unpubl. data). We have also used radiotelemetry to investigate the effectiveness of reptile conservation strategies, including the responses of Eastern Box Turtles to relocation (Hester et al. 2008) and habitat selection in Eastern Mud Turtles (Harden and Dorcas 2008).

We have found that undergraduate research is often facilitated by focusing on systems familiar to students. Aquatic ecosystems are often studied extensively in introductory biology classes. Students are aware of the threats aquatic organisms face in urban settings and are interested in the conservation of aquatic ecosystems. Impervious surfaces, such as parking lots, driveways and roof tops, drastically alter the amount of water runoff, leading to devastating effects on stream water quality. Our students have found that stream salamanders prove to be excellent models for studying the effects of urbanization on stream ecosystems (Willson and Dorcas 2003). Other researchers have also noted the sensitivity of stream salamanders to urban development (Orser and Shure 1972) and as indicators of habitat and water quality (Welsh and Ollivier 1998; Southerland et al. 2004). Wetlands, ponds and lakes in urban settings also provide excellent sites to study amphibians and turtles. These animals are often abundant and we have found that they can be monitored effectively by undergraduate students using standard herpetological survey methods (i.e., frog calling surveys, turtle and minnow traps). Creation of urban retention ponds in neighborhoods allow for investigations of herpetofaunal colonization rates and habitat use. Wetlands in urban areas often have exotic vegetation and numerous predators of amphibians and reptiles (Richter and Azous 1995). These stressors on amphibians and reptiles are well known, but not well studied in urban areas.

Urban and suburban environments provide excellent locations to investigate various additional impacts of urbanization on reptiles and amphibians. These investigations may bridge multiple disciplines (e.g., physiology, genetics) and have been developed by DCHL students who were experienced or had interests in these particular disciplines. For example, students interested in conservation genetics have conducted research on the genetic consequences of isolation in aquatic turtles and salamanders. A crucial aspect of developing effective undergraduate researchers and projects that are likely to succeed is a firm understanding of the student's interests as well as his or her particular strengths and weaknesses. Such understanding

develops over time and we try to use this knowledge to help the student develop research interests and projects that maximize their chances of success.

#### LONG-TERM STUDIES IN URBANIZED ENVIRONMENTS

Long-term projects that transcend the research of any individual student provide data and context through which individual projects can be developed. This provides students with the opportunity to conduct a project within a short time frame using data they collect in conjunction with data collected by previous students, sometimes years before they have arrived. Such extended studies also maintain a continued interest by former students who return to Davidson College to participate in ongoing projects and who also can offer advice to current students about pursuing graduate school or a professional career.

The establishment of the Davidson College Ecological Preserve (DCEP) in 2001 provided a large, protected area (approximately 90 ha) where numerous long-term studies of amphibians and reptiles can be conducted. In 1999, we constructed a 1000 m drift fence with pitfall traps (Gibbons and Semlitsch 1981) in the area that eventually became the DCEP. Later, we added funnel traps to the drift fence designed to capture larger snakes. We also set up several coverboard arrays that are periodically checked by students (Grant et al. 1992). The drift fence is monitored daily every spring and fall by students in the DCHL. Data from the drift fence and coverboard arrays have been used in two different student papers, one paper comparing historical and current perceptions of herpetological diversity (Rice et al. 2001) and another study examining the ecology of small fossorial snakes (Willson and Dorcas 2004). The protected DCEP also serves as a "control site," allowing students to study reptiles and amphibians in relatively unaffected habitats that can be compared with developed areas (e.g., Willson and Dorcas 2003; Budischak et al. 2006).

In addition to the drift fence and coverboard arrays, we have established a long-term, mark-recapture study of semi-aquatic turtles in our area using local farm ponds and ponds associated with neighborhoods (e.g., golf course ponds) as the primary study sites. This long-term study has provided opportunities for several undergraduate projects, including a project examining the impacts of cattle on semi-aquatic turtle populations (Lindsay and Dorcas 2001), a demographic study of semi-aquatic turtle populations (Thawley and M. Dorcas unpubl. data), a study examining body temperature variation in free-ranging Painted Turtles (*Chrysemys picta*; Grayson and Dorcas 2004), and a study comparing populations of turtles inhabiting golf course and farm ponds (Failey et al. 2007). A similar long-term mark-recapture study of Eastern Box Turtles has allowed students to investigate spatial ecology and activity patterns (Budischak et al. 2006), the natural history of Eastern Box Turtles in an urbanized landscape (Hester et al. 2008), and the responses of turtles when trapped between railroad tracks (Kornilev et al. 2006).

### COLLABORATIONS WITH OUTSIDE ORGANIZATIONS

Davidson College's location within a large urbanized region provides numerous opportunities for collaborations involving undergraduate students with other organizations. We have found that interactions with outside organizations greatly enhance the range of possible endeavors available to our undergraduate students. Such inter-organizational interactions have primarily taken three main forms: 1) collaborations with faculty and students at other colleges and universities, 2) collaborations with government organizations, and 3) interactions with private companies and institutions.

Involving undergraduate research students in collaborative work with colleagues and students at other institutions is beneficial to all parties involved. Urbanized regions typically contain many small colleges and often one or more large universities where effective collaborations can be initiated. Some faculty may be reluctant to allow undergraduate students the freedom to interact with their colleagues at other schools, but we have had several interactions that have worked exceptionally well. Care must be taken to discuss the expectations involved in such collaborations with both undergraduate students and the students or faculty members at each institution.

We have had considerable success conducting undergraduate-based research working closely with governments at numerous levels. Most of these interactions have been at the town (city) and county levels, with some state-level collaboration as well. Close interactions between DCHL personnel and local town planners have provided valuable information on potential study sites slated for development. This has provided us with unique opportunities to develop landscape-level experiments where we can study populations of amphibians and reptiles before and after development occurs. Collaboration with local government agencies has also greatly assisted in our interactions with land developers and has provided information on numerous potential study sites. For example, Mecklenburg County's natural resources department has several nature centers and wildlife preserves that offer excellent areas for undergraduate students to conduct research. These centers are in close proximity to Davidson College and given the rate of urbanization occurring in the Charlotte-Metro area, represent some of the few remaining large areas of protected land.

Collaborations and interactions with private organizations have been extremely beneficial to our undergraduate student researchers. We have worked closely with two different land conservancies (The Catawba Lands Conservancy and the Davidson Lands Conservancy) to identify potential study sites protected by these organizations through conservation easements or through direct purchase. In turn, the research that our students conduct on these protected properties provides these organizations with information important to effective land stewardship.

### COMMUNITY INVOLVEMENT

Because all herpetologists interested in conservation should be instilled with a strong sense of responsibility for education of the public, herpetologists in urban settings are in an ideal situation to educate and influence many people. We use herpetology to send a general message about conservation and an appreciation of our natural environments. We have found that most undergraduate students interested in conservation-based research are especially motivated to participate in outreach opportunities. Consequently, undergraduate researchers in the DCHL regularly give talks to local public and private schools, scout troops, and other groups. On a yearly basis, we have "Davidson Reptile Day," a family-oriented, hands-on event where community members can come to Davidson College and learn about amphibians, reptiles and their conservation first hand. This event typically draws between 500 and 700 people and is primarily organized and conducted by undergraduate students.

We have found that close and regular interactions with local community members can prove to be invaluable resources for our research. We established two programs that serve as mechanisms by which we can achieve education and research goals simultaneously by involving the public in conservation-based herpetological research. Both of these programs are coordinated by undergraduate students. One of these programs, the Catawba River Corridor Coverboard Program, uses coverboards as a sampling technique by which local schools, nature centers, and other organizations can survey and monitor amphibians and reptiles (Pitman and Dorcas 2006). All instructions, data-sheets, and databases are available online ([www.ccari.org/crc-cbp/cbhome.htm](http://www.ccari.org/crc-cbp/cbhome.htm)) and each organization submits their data electronically.

In addition to the Coverboard Program, the DCHL has developed a Box Turtle mark-recapture program that primarily relies on community members. Faculty, staff and students at Davidson College participate in the program, but many of the turtles have been collected by community members (Hester et al. 2008). Community members collect turtles, bring them to the DCHL for measuring and marking, and then return them to their capture location. Data from this program have been used as the basis for several undergraduate student research projects.

### CHALLENGES OF WORKING WITH UNDERGRADUATE STUDENTS

Developing quality research projects with undergraduate students poses challenges not normally associated with similar research with graduate student participation. These challenges often transcend the field of study and the environment in which the research is conducted. However, addressing how we try to manage some of these challenges may be useful to others working primarily with undergraduate students. Challenges associ-

ated with undergraduate students conducting research include a relatively short time frame in which students are required to conduct research projects, a lack of research experience by most undergraduate students, and time that students must devote to heavy course loads and other activities. Nevertheless, we have found that meaningful projects can be developed within the constraints posed by an undergraduate-based research program and that some undergraduate students can produce work that rivals typical research conducted by graduate students.

One of the strategies that we have taken is to attempt to recruit students early in their undergraduate careers. Often, students who are interested in conducting research may not initiate such opportunities until late in their third year, thus limiting the type of project that could be conducted before they graduate. We have found that having an informative website ([www.bio.davidson.edu/dorcas](http://www.bio.davidson.edu/dorcas)) sometimes attracts herpetologically-oriented students to apply to Davidson College and facilitates their involvement in research early on. Recruiting promising students from introductory classes can also help them get involved in research early and increases the number of possible projects students can become involved in because they are not limited to only a few months in which to conduct their research. Furthermore, freshman and sophomore researchers often provide meaningful assistance to juniors and seniors while they learn research techniques.

Unlike graduate students who conduct research in herpetology, most undergraduate students do not begin with a predisposition to becoming a herpetologist. However, having a positive and rewarding experience conducting research on amphibians and reptiles often results in students considering herpetological research as a potentially viable career choice. In the DCHL, we have had several students go on to work on their M.S. or Ph.D. degrees in herpetology. Others that decide to pursue other fields of study often benefit from their experiences as herpetological researchers.

Another strategy that we use is to keep an ongoing list of potential project ideas. Often, during the course of conducting research or while in the field for other purposes, ideas are generated for new projects or questions that can be addressed. Recording these ideas and consolidating them into a single list allows us to provide interesting ideas to students when they initiate discussions about potentially conducting herpetological research. In addition to this list, we maintain and update a document called "Herpetology Laboratory Protocols and Guidelines" that outlines expectations of students working in the lab, procedures for how animals are processed and cared for in the laboratory and field, and safety considerations. Providing this document to new researchers and expecting them to be familiar with its contents greatly assists in getting students "up-to-speed" quickly with laboratory procedures.

Finally, a major key to success is our development of strong working relationships with students. We hold weekly DCHL meetings where we discuss lab research projects, outreach events and other miscellaneous activities. Each DCHL member is also assigned specific responsibilities (e.g., animal care, database

manager), which are also discussed during our weekly meetings. The assigning of responsibilities greatly increases the productivity of DCHL and helps students build confidence as scientists and lab members. Students who are conducting independent research also meet with us on a regular basis when we are able to discuss their projects in detail. Students new to the lab are encouraged to help independent researchers with their projects. The relationships we developed with many of the students continue after their graduation from Davidson College; several have developed into colleagues with whom we still collaborate.

Despite the limitations associated with working with undergraduate students, their abilities should not be underestimated. If mentored in the proper way, some students have the ability to produce high-quality research, present research at professional meetings and publish in high-quality scientific journals. Between 1998 and 2007, more than 50 presentations have been given by undergraduate members of the DCHL, some of which have won awards, and over 30 papers have been published by DCHL students.

Although this chapter has focused on the strategies and accomplishments of the DCHL in particular, similar success has been achieved at other primarily undergraduate institutions. The herpetology program at Stetson University (Terry Farrell and Peter May) in Florida serves as an outstanding example of a laboratory that has provided opportunities for many undergraduate students to become involved in research since the mid 1990s. Stetson's research on Pygmy Rattlesnakes (*Sistrurus miliarius*) and other amphibians and reptiles is based primarily on undergraduate student involvement and has resulted in many papers and presentations coauthored by undergraduates (e.g., Jemison et al. 1995; May et al. 1996; Rabatsky et al. 1996). Likewise, herpetological research in an urban setting at Harding University (Michael Plummer) in Arkansas has focused on a wide variety of species and topics and depends heavily on collaborations with undergraduate students (e.g., Plummer and Mills 2008). These and other institutions serve as excellent examples of how herpetological research can provide unique and rewarding opportunities for undergraduate students while contributing to our understanding of urban herpetology.

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