SOAR Research Proposal - Summer 2012

Project Title: ***Snout and jaw mobility in sand boas: balancing conflicting functional constraints***

Faculty Advisor: Dr. Frances Irish, Assistant Professor of Biological Sciences

Students: Victoria Womer and Amarnath Kandallu

Project start date: May 29, 2012 **Project duration**: 10 weeks

Background information: Snakes have highly kinetic skulls. The snout and upper jaws are movably attached to the braincase by ligaments, allowing snakes to move the jaws on each side of the head independently. When swallowing, snakes anchor the prey with the jaws on one side of the head while advancing the jaws on the other side, thus "walking" the head over the prey. Because the snout is tied to the upper jaws by connective tissue, the snout passively rotates up and down to track upper jaw movements. The ability of the snout and upper jaws to move freely is an integral part of the unique unilateral feeding mechanism of snakes. For snakes that keep their heads above ground, this kinetic ability is an advantage. But when the head is used as a shovel for burrowing, having a collapsible snout becomes a problem. The question addressed in this project is: how do sand boas, a group of small, burrowing boas, balance the conflicting demands of burrowing and swallowing?

Relevance: This project explores a question of vital interest to evolutionary morphologists: how do musculoskeletal systems adapt to conflicting functional demands? Most burrowing snakes show some kind of reinforcement of the snout-braincase connection; this project is a first step in figuring out how reduced snout movement affects snake feeding mechanics. But the project has broader implications for the evolution of snakes. Evidence from skull and eye anatomy suggests that snakes may have evolved from burrowing ancestors. How did the highly kinetic, unilateral feeding system of snakes evolve from a skull reinforced for burrowing? Looking at how extant burrowing species have solved this problem may shed light on snake origins.

Results from summer 2011 SOAR project:
Preliminary data suggest that, contrary to our expectations, the snout does *not* closely track the upper jaws in sand boas----in fact, when the snout is raised during prey capture and swallowing, the anterior ends of the upper jaws are depressed (i.e., jaws and snout move in opposite directions). The students will present the results of their project at Scholar's Day and the Lehigh Valley Evolution and Ecology Symposium at DeSales University in April.

Description of proposed summer 2012 SOAR project:
Preliminary results from summer 2011 are intriguing, but we need more analyzable data. The proposed 2012 project addresses challenges encountered in 2011. Students will:

1. Read relevant literature on snake feeding mechanics.

2. Examine the soft-tissue connections between the snout and upper jaws in preserved sand boas and other relevant species through dissection.
3. Figure out how to put high-contrast, non-reflective landmarks on the snakes' heads to facilitate analysis.
4. Record strikes to prey on high-speed video (preliminary high-speed data from last summer suggest that strikes entail higher amplitude snout and jaw movements than swallowing, making movements easier to measure).
5. Record prey manipulation and swallowing at "normal" speed from dorsal and lateral views simultaneously in order to track movements in 3 dimensions.
6. Do frame-by-frame analysis of video records, measuring snout and upper jaw movements.
7. Place the data in a comparative context by recording feeding in other boas.
8. Synthesize results for presentation and possible publication.

Two students are needed for this project because it is nearly impossible to keep the camera in focus and feed the experimental subjects at the same time. I also believe the experience will be more valuable if the students come to "own" the project by being allowed some level of autonomy---i.e., being able to conduct recording sessions by themselves. Last summer the synergy between the students was extremely fruitful.

Experimental animals: 35 specimens of 9 species of erycine boas, currently housed in the animal facility at Moravian College. Species to be used for comparison will be borrowed from the snake facility at Lehigh University. Students will maintain experimental animals and their prey (juvenile mice) during the course of the study. Protocols for the first phase of this project, conducted with SOAR funding in summer 2011, were approved by the IACUC committee at Moravian College.

Roles and responsibilities of faculty and students:
Faculty role: I have been involved in filming snakes feeding for the past 10 years, and have studied snake anatomy extensively through gross dissection, histological study, and skeletal preparation. I will aid the students in their literature search, instruct them in experimental techniques, use of specialized equipment, data analysis, and appropriate care of animals, and guide them in preparing their results for presentation.

Student role: Though the proposed project is part of an on-going research program, the students will participate in all aspects of the work, from animal maintenance to experimental design, data gathering, data analysis, and presentation, as outlined above.

Project timetable:

Week 1: Instruct students in animal maintenance chores; supervise literature search; familiarize students with snake head anatomy; prepare experimental arena.
Weeks 2-8: Record snakes capturing and swallowing prey; analyze resulting data each day; continue doing relevant dissections and drawings.
Weeks 9-10: Finish data analysis, synthesize experimental and anatomical data for presentation, prepare poster.

Student engagement in scholarly research and contributions to the discipline:

Both of these students are currently planning a medical career, so familiarity with the techniques of gross dissection and experimental morphology should have particular relevance for them. I have taught both of these students in General Zoology (Biology 112), and Amarnath also took Mammalian Anatomy (Biol 310), so they have had some experience with dissection, as this is an important aspect of the lab in these courses. However, this project will require them to do micro-dissections of small specimens and elucidate the anatomy without the aid of a dissection manual, as the anatomy of these small snakes is poorly known, and the aspects we wish to study are not known at all. Amarnath has expressed interest in doing an honors project with me next year and the proposed summer research would lay the groundwork for that project. Hands-on research experience and formal presentation of the results should make both students more competitive in applying to medical school, and better prepared to succeed. Students will prepare a poster and present their work for their peers at Moravian College, and also at the Lehigh Valley Evolution and Ecology Symposium in 2013.

This project stems from observations made during a long-term study of prey capture behavior in boas and pythons that I have been pursuing in collaboration with Dr. David Cundall of Lehigh University. Early data have been published, but given the fact that these animals are ectothermic and are adapted to going without food for long periods of time, amassing a large data set takes time, patience, and ingenuity. A critical part of my job is mentoring undergraduates in a research setting. The project outlined here is publishable material; data collected this summer will be vital to finishing the experimental aspects of the research so results can be submitted for publication in a peer-reviewed journal.

In today's world, where we enjoy many of the benefits of scientific discovery, it is vital that our students understand the nature of science and the process by which scientific discoveries are made. Having our biology-bound undergraduates actively engaged in scientific discovery brings hands-on science into the community of undergraduate scholars at the college. Formal presentation and eventual publication of student-faculty collaborative research enhances the reputation of Moravian College, and is a selling point for prospective students.

Budget:

$6000	Summer stipends ($3000) for each student funded
$1750	Faculty stipend
$ 850	Panasonic HDC-HS900 digital camcorder and tripod [needed in order to film two views simultaneously---feeding movements in these animals are very complex; placing these movements in 3 dimensions will greatly improve our analysis]
$ 150	Supplies: Dissection material, animal food, bedding, etc. (The Moravian College Department of Biological Sciences will supply additional equipment and supplies.)
$8750	Total

Snout and Jaw Mobility in Sand Boas: Balancing Conflicting Functional Constraints

Student: Amarnath Kandallu, Biochemistry major, 2013

Faculty Mentor: Dr. Fran Irish

On-Campus Housing: Not Required

My reason for participating in a SOAR project is so I can acquire experience in scientific research. I am a biochemistry major and I am planning on applying to medical school this summer. A research experience through SOAR would give me a greater understanding of the medical field by introducing me to methods that are used in medical research. A research experience will also help strengthen my resume and medical school application. I will be more prepared for medical school because it shows that I am dedicated and willing to work hard. I will have a greater appreciation for science by obtaining hands-on experience. SOAR will also help me enhance my skills as a scientist, and offer an opportunity for me to be able to join a community of students engaged in research.

I have taken many science classes in my college career and most of them have a lab portion, which allows students to apply theory learned in class to an experiment. A SOAR project will give me the opportunity to conduct original and independent research. I have taken Zoology and Mammalian Anatomy with Dr. Irish and I have been introduced to snake anatomy. As I learned in Mammalian Anatomy, there are differences and similarities between humans and snakes. Humans, for example, have an akinetic skull whereas snakes have a kinetic skull. In medical school I will have to learn a vast amount of human anatomy and by doing this SOAR project on snake anatomy I will be able to appreciate the value of anatomy.

This SOAR project would further increase my knowledge of how structure defines function and how function defines structure. I hope I will be able to increase my ability to analyze new data and come to reasonable conclusions. If I am given this opportunity I would be able to acquire a valuable research experience.

SOAR Student Statement of Purpose February 28, 2012

Snout and Jaw Mobility in Sand Boas: Balancing Conflicting Functional Constraints

Student: Victoria Womer, Biochemistry Major, Graduating 2013

Faculty Mentor: Dr. Fran Irish

On-campus housing requested

The sciences encompass a diverse group of employment and post-undergraduate opportunities. Currently I am focusing on a career in medicine. The medical field is a competitive path to follow that requires years of study and training. Medical schools look for a number of things on applications. In many schools one of those areas is research experience. Some physicians participate in research studies while practicing medicine and even go through clinical trials. Research is a huge part of how the medical field grows and prospers. In order to put a foot in the door of research, I looked into the SOAR program.

Participating in a summer research project contributes to a more competitive medical school application. It shows dedication to a particular subject of interest and shows a determination to succeed. The experience is also an insight into how I can handle a research setting and how successful I can be. A research position is also a good conversation topic for an interview. It would give me a chance to show that I have a passion for learning. The project also requires the presentation of a poster representing the research we conducted. Physicians give presentations and speeches to coworkers and colleagues all the time. Being able to present scientific information shows schools I am prepared and gives me a step up on other applicants.

I asked Dr. Irish if I could be a part of her particular research project with snakes because I enjoy working with the animals in the greenhouse. As a work-study job, I feed and housekeep for the creatures in the greenhouse. They all have curious behaviors that differ from each other and vary from month to month. Learning more about how animals function and adapt is a curious interest of mine that led me to this summer research project.

I also feel this study would benefit my long term career goals. The research would require me to learn about the anatomy of this particular group of snakes as well as the comparison to other species. Learning anatomy will be a key component of my studies in the future. Studying a less well-known anatomy will give me insight into looking at patients whose anatomy differs from the norm, or conditions that alter human anatomy. The project also includes experimental morphology, which looks at the external factors affecting the morphology of an organism, in this case the sand boa. Knowing the specific structural features of organisms helps scientists place the organism into its proper taxon. This helps scientists and doctors who want to do clinical trials choose an organism that most closely resembles the part of the human anatomy that they wish to study. It also helps us to understand the functions of the human body by using 'model organisms.'

For this project I expect to further investigate snout and jaw mobility in sand boas. I anticipate learning the anatomy of the snout and jaws, and comparing and contrasting it to other snake species. I also look forward to learning how a research project is designed, and how data are collected, compiled, and analyzed in experimental morphological studies.