SOAR Research Proposal
Summer 2016

How do sand boas capture prey they can't see?

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

Student: Michelle Pomposello

Project start date and duration: May 31, 2016 (10 weeks)

Background for the project: 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 loosely tied to the upper jaws by connective tissues, we expect that the snout will passively 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, but for burrowing snakes like sand boas, having a collapsible snout could be a problem. Are snout movements in these snakes constrained by structural modifications that resist the stresses of burrowing?

Data from SOAR projects in 2011, 2012, and 2014 indicate that contrary to our initial expectations, the snout does *not* closely track the upper jaws in sand boas----in fact, when the mouth is opened, the snout is raised and the upper jaws are depressed (i.e., snout and upper jaws move in opposite directions), suggesting that the snout and upper jaws show surprising independence of movement. Why might depressing the anterior ends of the upper jaws be advantageous during prey capture?

Sand boas are classic sit-and-wait predators that often snag prey from beneath the soil surface, where their field of vision may be obstructed and stalking would reveal their presence. When the snout is maximally elevated during the strike, the anterior ends of the upper jaws are strongly depressed and rotated outward, so that the mouth appears to be bristling with teeth. We hypothesize that this results in maximum tooth exposure and increases the likelihood that prey will be snagged successfully. But our observations are limited to feeding events recorded in a bare filming box. We have not recorded snakes capturing prey from beneath the substrate because snout rotation, the primary variable measured in previous studies, is obscured by flying particles under these conditions. Although it is difficult to directly test our hypothesis, we can ask some interesting questions: What is the success rate of prey capture under these conditions? What sensory modalities are being used to detect prey? Do sand boas hide their heads completely, or are they able to see their prey?

Relevance: In essence, sand boas are using their upper jaws and teeth like erectable fangs to capture their prey. This is reminiscent of what vipers and pit-vipers do, except that in sand boas the maxilla (the upper jaw bone bearing the teeth) rotates in the opposite direction. This has interesting implications for the evolution of mobile jaws in snakes and may have bearing on the evolution of venom delivery systems.

Description of proposed summer 2016 SOAR project: We plan to record sand boas capturing prey in a more naturalistic setting, concealed beneath the substrate. An aquarium will be used for filming that has a mirror mounted at a 45^{o} angle so the snake can be filmed from the top and side simultaneously. We will work primarily with *Eryx colubrinus,* as we have 11 specimens and they are among the most tractable sand boa species under experimental conditions. The student will:

1. Read relevant literature on prey capture in snakes.
2. Record strikes to live prey on high-speed video (500 frames per second).
3. Do frame-by-frame analysis of video records.
4. Examine the connections between the braincase, snout, and upper jaws in dried skulls and relevant preserved specimens in order to discover how the upper jaws are depressed in *Eryx*.
5. Synthesize results for presentation.

Experimental animals: All of the sand boas to be use in this project are currently housed in the animal facility at Moravian College. The student will help maintain experimental animals and their prey (mice) during the course of the study. Protocols for the previous phases of this project were approved by the IACUC committee at Moravian College, and approval will be sought for summer 2016 as well.

Roles and responsibilities of faculty and students:
Faculty role & responsibilities: I have been filming snakes feeding for the past 15 years, and have studied snake anatomy extensively through gross dissection, histological study, and skeletal preparation, and I am a co-author on two book chapters on the snake skull and prey capture kinematics. I will guide Michelle in her search for background literature, instruct her in experimental techniques and use of specialized equipment, assist her in data collection, data analysis, and appropriate care of animals, and help her prepare her results for presentation.

Student role and responsibilities: The proposed project is part of an on-going research program, but Michelle 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 student in animal maintenance chores; supervise literature search; familiarize student with snake head anatomy; prepare experimental arena and design experiments.

Weeks 2-8: Record snakes capturing prey; analyze resulting data; relate observed kinematics to head anatomy.

Weeks 9-10: Finish data analysis, synthesize experimental and anatomical data for presentation, draft poster.

Student engagement in scholarly research and contributions to the discipline:

Michelle took General Zoology (Biology 112) from me and she is currently acting as my Teaching Assistant in Zoology lab this semester, so she has had preliminary background material that should help her understand the context of this study. However, this project will require her 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. Michelle has not yet settled on a career path, but she has expressed interest in pursuing a postgraduate degree. Hands-on research experience and formal presentation of the results should make her more competitive in applying to graduate or professional school, and better prepared to succeed. She will present her work for scholar's day at Moravian College, as required, and for an audience of peers beyond Moravian College, such as the National Conference on Undergraduate Research and the Lehigh Valley Evolution and Ecology Symposium.

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.

Expense proposal

Project title: ***How do sand boas capture prey they can't see?***

Faculty mentor: Dr. Frances Irish

Student: Michelle Pomposello

$ 100	Expendable supplies. Includes dissection materials, animal food & bedding, additional research animals (if required), etc. The primary research equipment for this project (cameras, lights, filming box, computer software, etc.) is available in house. The Department of Biological Sciences will supply additional equipment and supplies if required.
$ 100	Total

Student Statement of Purpose
Summer 2016

How do sand boas capture prey they can't see?

Student: Michelle Pomposello
Major: Biochemistry
Expected date of graduation: May 2017
Faculty Mentor: Dr. Frances Irish
Request for on-campus housing: Yes

My name is Michelle Pomposello and I am a sophomore Biochemistry major at Moravian College. I have experience in an array of science courses that include Chemistry, Organic Chemistry, Chemical Research Methods, Zoology, and Genetics. I am currently enrolled in Organic Chemistry II and Cell Physiology and will have completed these courses by May of this academic school year (2016). I also serve as a Teaching Assistant in Zoology. Using my skills in research and scientific writing as well as the knowledge gained from these courses I hope to work on a SOAR project with Dr. Irish on prey capture behavior in sand boas. This research would include handling the snakes used in research, using the high speed camera to record prey capture, analyzing the functions of anatomical structures, as well as gaining behavioral knowledge of these animals. This research is specifically interesting to me because I have a fascination with snakes and have always been intrigued by their habits. My friend in high school had three snakes and I loved handling them and watching how my friend would care for them. This research would allow me to further explore my interest in snakes. Furthermore, I have been debating a career in the field of medicine as well as one in the field of research. I am very passionate about science, specifically Zoology and Chemistry, and so working with Dr. Irish on a project that directly relates to Zoology would be beneficial to my educational success. The duties required of me in this research project would give me significant insight into the world of research. It also would give me experience in studying the function of specific structures in snakes, much like medical students study humans. This, along with the behavioral aspect of this project, would serve as background in anatomy and physiology. Also, this SOAR project would be incredibly beneficial in helping me decide on which path I want to take for my career.