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Validating an automated classification system for snake movement behavior: refining and extending the radio telemetry-accelerometry framework

Dominic L. DeSantis

Faculty Grant Report

Project Title: Validating an automated classification system for snake movement behavior: refining and extending the radio telemetry-accelerometry framework

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Job Title: Assistant Professor

Awarded funding: $5,000.00

Project Abstract (250 words or fewer)

An animal's behavioral decisions, such as when, why, and how individuals move through their environment, are mediated by a complex interplay between internal (e.g., sex, physiological state, motivational state) and external (e.g., environmental conditions, predation, competition) factors. A detailed understanding of the causes and consequences of these decisions for many species has historically been precluded by methodological constraints. However, a recent wave of advancements in sensor technologies circumvents many of these traditional limitations and has spurred the emerging field of biologging science. Animal-attached dataloggers (or biologgers) give researchers the ability to remotely monitor an individual's physiology and behavior in the field at resolutions and precisions historically restricted to laboratories. Accelerometer dataloggers, specifically, are small (< 1 g) piezo-electric (spring-like) sensors that measure three-dimensional acceleration (upward, downward, and side-to-side) derived from subject motion, enabling interpretation of a wide range of movement-mediated behaviors. This project aims to expand on a recently developed framework for accelerometer monitoring in snakes, a group that has otherwise been completely overlooked in biologging applications. The proposed validation procedures are the essential first step toward translating these techniques to field applications, and, ultimately, improving analysis of the relationships between snake behavior and key internal and environmental variables.

Project Description

Specific Aims/Objectives (350 words or fewer)

Provide a detailed description of your work, including how/why you approached the research question(s).

The overarching objective of this project is to refine and extend the radio telemetry-accelerometry (RT-ACT) framework. The RT-ACT validated the use of accelerometers for monitoring snake activity in the field (DeSantis 2019). Prior to this, there was no available method for remotely and continuously recording wild snake behavior. However, the classification models developed by DeSantis (2019) only distinguish coarse-scale behaviors (active vs. inactive). To fully realize the potential of the RT-ACT in ecological and conservation-oriented research, the classification of additional behavioral states must be validated. Therefore, the underlying goal is to increase the number of snake behavioral states that can be accurately classified from accelerometer signals using machine learning techniques.

Why snakes?

Despite their absence from accelerometer studies, snakes represent intriguing model organisms for such applications. As ectotherms, snake behavior is tightly linked to external factors (Beaupre 2016), making them ideal study subjects when considering interactions between behavior and environmental conditions (Shine and Bonnet 2003). Snakes are also often numerically dominant relative to sympatric avian and mammalian predators (Willson and Winne 2015), facilitating the manageable study of a large sample within a relatively small area. Lastly, snakes are highly amenable to internal implantation procedures (Hardy and Greene 1999, 2000), allowing long-term field monitoring via implanted radio transmitters and accelerometers.

Why RT-ACT?

Significant gaps in our knowledge of behavior and ecology remain for most snake species because of their secretive life histories (Dorcas and Willson 2009). Efforts have been made to improve our ability to monitor snake movement behavior in the field, such as the development of automated radio telemetry arrays (Ward et al. 2013). However, these approaches are constrained by snake proximity to fixed-point antennas, and identifying discrete behaviors still requires direct observation. Accelerometers eliminate these limitations by recording activity independent of observer presence, terrain, weather, time of day, and scale of space use (Yoda et al. 1999; Wilson et al. 2006). However, radio telemetry remains the most useful technique for measuring snake space use. Therefore, the RT-ACT integrates the strengths of both technologies to simultaneously provide data on the temporal and spatial dimensions of snake movement behavior.

Research Methodology (250 words or fewer)
Describe your research methodology being sure to describe the materials and methods used.

Below are the methods for our originally proposed captive experiments. As a result of COVID-related restrictions on student research indoors that were imposed briefly after I received this funding, we were forced to pivot towards pursuing the field-based protocols of this project to more safely facilitate student participation.

Captive observation experiments will be conducted with the Timber Rattlesnake, Crotalus horridus, a large bodied and abundant pitviper found throughout southeastern North America. At least two adults (one male, one female) will be collected from the field and returned to Herty 105 for observation trials. Individuals will be equipped with an externally attached accelerometer (via temporary gluing) to record targeted behaviors: 1) full-body rectilinear and serpentine movement, 2) climbing movement, 3) aquatic movement, 4) reproductive behavior, and 5) predatory behavior. Trials will occur within 150-L glass aquaria or a 2.5-m x 1.25-m plywood enclosure. During the initial trial phase, individuals will be placed under constant video recording in the enclosure for two hours to observe behavioral states 1–3. After this initial phase, reproductive and predatory behaviors will be stimulated by introducing one of either a mating partner or prey item into the enclosure.

Behavioral states within the video datasets will be manually annotated at a 1-sec. resolution. These “ground-truthed” datasets will be used in classification model validation procedures. Descriptive statistics will be calculated with the unprocessed acceleration data to aid in the interpretation of behavior. The Random Forest algorithm will be used to classify behavior. Random Forests make use of multiple decision trees to build a unified classification tree based on the random (unbiased) selection of data features. All model validation procedures will be performed in R (R Core, 2017).

Impact of Project (200 words or fewer)
Please tell us what you accomplished and the impacts of the project. How did the results of your research help the advancement of the discipline, your professional development, and/or course curriculum?

To date, our work in this area continues to operate on the frontier of biologging applications in snakes and other small-bodied wildlife. The preliminary results from ongoing field work have translated to four student presentation at local and regional meetings. The FRG funding has also supported a critical aspect of Anna Tipton's thesis (MS student that began work in my lab in September 2020). Following these presentations, I have established working collaborations with several colleagues that were in attendance and are now working to implement the RT-ACT framework in their own research. One of these collaborations facilitated a large interdisciplinary grant proposal submission (not funded, see below).

Next Steps
Dissemination of Results (100 words or fewer)
Describe how you have or plan to share the results of your project, within and/or outside of the GC community.

In addition to my students and I continuing to present the results from our field research at conferences (four student presentations, to date – three posters and one talk at three regional meetings), we will also prepare and submit manuscripts for publication. Our goal is to prepare at least two papers directly related to the activities supported by this funding, one-two for the field project and one focused on the captive validation experiments that will be launched once my incoming MS student (Morgan Thompson) begins her thesis research this summer 2021.

Efforts of project leading to outside funding
Indicate outside sources from whom funding has been requested for future development or expansion of this project. If none, please describe steps you will take to request additional funding for your project.

Anna Tipton (MS student, Biology) and I submitted a research proposal to the Herpetologists' League EE William Student Research Grant competition in December 2020. Awards will be announced in April or May 2021. This work would represent an extension of the field project supported by the FRG.

With colleagues from San Diego State University and Cal Poly, I submitted a proposal to the Department of Defense Strategic Ecological Research and Development Program in January 2021. While this large interdisciplinary project incorporating the RT-ACT framework was not funded, the process did facilitate what I expect to be fruitful collaborative relationships with several outstanding colleagues. One of these colleagues (Dr. Rulon Clark , San Diego State University), delivered a guest presentation for our Dept. Biological and Environment Science Talks (BEST) seminar in March 2021. Rulon and I are currently exploring new funding opportunities to pursue while jointly working to enhance our proof-of-concept results in the meantime.