Office of Undergraduate Research & Scholarship
2019 Summer Undergraduate Research and Fellowship Application

Proposal Title: Effects of Royal Jelly and Juvenile Hormone on Growth and Immunity in *Gromphadorhina portentosa* (and application to science outreach in Virginia and surrounding areas)

Student Name: Taylor Hawkins

RU ID: 900817091

Email: thawkins18@radford.edu

Cellphone Number: (443) 944-6299

Objective one: *Determine the influence that exogenous hormone modulation, through administration of royal jelly and juvenile hormone, has on energy investment in immunocompetence and self-repair in Madagascar hissing cockroaches.*

Background: Invertebrate endocrinology is a subject far too commonly overlooked and underappreciated, in part because the complex web of hormonal interactions and energy investment strategies of invertebrates are not clearly comparable to that of vertebrate species. While vertebrates are often used as a biological model for medical applications, research on invertebrate endocrine function might hold more answers as a result of understanding their extreme diversity and strategically evolved survival mechanisms. In this project I propose to investigate the multidimensional energetic investment strategies that invertebrates depend on for survival and how we can use this information to better interpret patterns of physiological evolution across multiple and diverse taxa.

For the past three years I have been project leader on this study, which has led to both poster and oral presentations at international comparative and integrative biology conferences and multiple internal and external grant awards. By continuing the discovery of unknown energy investment mechanisms regulated by the endocrine system, I will be able to publish results that will contribute to the relatively unexplored realm of invertebrate hormone systems.

Methods: Three treatment colonies of cockroaches (royal jelly[4], juvenile hormone[11], and royal jelly in combination with juvenile hormone), as well as a control group and an immune inhibited group[6], have been reared in ad libitum conditions for 18 months. Four cockroaches from each group, including control, will be examined per test interval (each cockroach will recover for ten days between blood sampling). Each cockroach will be bled in order to remove hemolymph, and then the sample will be immediately centrifuged and combined with defibrinated rabbit blood. Each sample will be assayed using three tests: blood slide analysis, coagulation diameter and color value, and spectrophotometric analysis. Each assay will be used to interpret the immune response between the cockroach's hemolymph and the immune stimulant: rabbit blood. I will also observe glutathione peroxidase in hemolymph to better understanding changes in self-repair/antioxidant production associated with each hormone treatment. During the testing period, the subject animals will also be weighed and measured to determine if growth also has an impact on immune investment under varying hormone treatments.

A second round of testing will occur during the latter half of summer 2019 using cockroaches in food restricted conditions. The treatment groups will be identical to that described above but will include animals fasted for several weeks prior to testing, in order to explore the impacts of energy restriction on immune function under hormonal modulation. This will provide vital information about how animals prioritize systems for survival and gene continuation[8,10].

Preliminary data: Due to the fact that I am creating my own assaying system for observation of invertebrate immune function, our current results are limited to 12 cockroach samples per group. During an oral presentation at the Society for Integrative and Comparative Biology conference, I described these results suggesting that royal jelly acts similarly to thyroid hormone in vertebrates by increases a wide range of systems including immunity, growth, and reproductive investment. I suspect that life expectancy is compromised due to increased energy investment in other primary systems. Conversely, royal jelly in combination with juvenile hormone impairs immune function and reproduction, while emphasizing growth and secondary sex trait expression[3]. Continuing this research will also allow us to understand the long-term adverse effects that commonly used pesticides and herbicides have on invertebrate species.

Objective two: *My research from Radford University's Davis Ecophysiology Laboratory will be displayed as Radford's Roach Roadshow- a series of outreach events developed to teach the general public about endocrine research and what being a scientist means.*

Background: Laboratory work is a necessary and valuable aspect of progressing society. However, the general public must be able to understand scientific work in order for these innovations to make a profound difference in the lives of the masses. As described by the National Science Foundation (NSF) in grant proposals, non-research based broader impacts are crucial to the integrity and development of the scientific community[7]. These values, along with my past three years of outreach experience, have served as the foundation for my mission to improve science communication by putting my own research into the public eye.

Radford's Roach Roadshow (RRR) My outreach program, Radford's Roach Roadshow, is a series of events in Virginia and surrounding areas that educates people of all ages about my current research, why research is imperative, and how audience members can become an "at home scientist." In order to help the community explore and delve deeper into the field of science, we have to show why science is interesting and how individuals with limited exposure to scientific research can pursue scientific questions. RRR provides a pathway that allows people to learn and grow in their understanding of science through a variety of teaching styles, all derived to maximize education retention in diverse audiences. Aspects of RRR classes include:

- *Children's story*: I have written a children's book to explain the impacts of royal jelly and juvenile hormone in our previous work using fruit flies (*Drosophila melanogaster*)[2]. We target a 7 to 9 year old audience to explain the results of our research in a way that makes kids think about their place in the world of STEM.
- *Immune research:* "Dr. Roach" is our mascot for explaining the immune system to children. Dr. Roach provides a visual understanding of just how important self-investment strategies are to long-term survival.
- *Sustainability stack:* We use a two-tiered, clear acrylic container with cockroaches on the top tier, and plants on the bottom tier to display recycling of food waste while simultaneously creating better fertilizer[1].
- *Build*-a-*Bug*: Through arts and crafts I will teach kids about animal adaptation
- *Investment scale*: Investment options will tilt the balance in demonstration of an animal's prioritize/compromise relationship in systems such as growth, immunity, or reproduction

By customizing interactive research pitches and demonstrations that target specific age groups and venue specific learning, we are better able to teach about adaptation, energy investment, immunity, life-span and sustainability[5,9]. Ultimately, this project highlights both, the necessity of increasing public knowledge of insects and endocrine physiology, and the value of public interpretation of science.

Summer 2019 Timeline

Hormone treatments have already begun and will continue until Spring 2020
May: Immune assays (methods from *objective one*), dissect cockroaches and examine sex differentiation and/or mutation, develop statistical analysis of immune assays, finalizing RRR designs, 3 outreach events (all events listed have been planned and approved by locations)
June: Study immune suppression and conduct assays using immunosuppressed cockroaches to control for unknow invertebrate immune reactions, 5 outreach events
July: Analyze assay results and begin starvation study. Draft first publication, 5 outreach events
August: Round two of edits on publication (target: Journal of Endocrinology), 7 outreach events

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