Faculty

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Student
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Title: Is resistance futile? Evolution of pesticide resistance in a common soybean pest

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II. Narrative

Project Description

Agriculture is the largest part of the Georgia economy, contributing more than $65 billion annually to Georgia's $786.5 billion economy. Insects play a vital role in all areas of agriculture, some as beneficial pollinators such as honeybees and butterflies, but others as pests that usually destroy crops by eating them. To combat the problem of destructive insect pests, farmers invest large sums of money annually in insecticides to kill the insects. In 2010 in Georgia, approximately $701.2 million (~ 16.5% of the total value of all crops) in plant crops were lost to disease/pests or spent trying to control the pests (Williams-Woodward 2010). Unfortunately, a common problem with long term and widespread pesticide application is that insects can evolve resistance to the pesticides, much in the same way that humans have evolved resistance to widespread use of antibiotics.

One of the most damaging crop pests in southern U.S. is a caterpillar, Psuedoplusia includes, that feeds on soybean leaves. Heavy infestations of these caterpillars can defoliate entire fields. They are eating machines! Outbreak populations of P. includens in soybeans cause significant damage, especially in southern states (Higley and Boethel 1994). Control of this caterpillar is generally managed by application of chemical pesticides, but it is increasingly difficult to manage these pests because the caterpillars have evolved resistance to a variety of insecticides, including organophosphates, carbamates, and pyrethroids, that have historically been used to manage it on the several crops it infests (Gianessi et al. 2002). This evolved resistance renders the pesticides useless for killing the caterpillars.

Because soybeans are such an economically important crop, chemical companies respond to pesticide resistance by developing new or more potent concentrations of chemical pesticides. Three relatively recently developed pesticides, for which there is no evidence of evolved resistance in P. includens, are spinosad, emamectin benzicate, and chlorphenypr (Mascarenhas and Boethel 1997). While there is no evidence that pesticide resistance has yet evolved, these are relatively new pesticides, so it is likely that populations will eventually evolve resistance. Spinosad is a widely applied, commercially available pesticide that is favored over many other pesticides because it is less toxic to the surrounding environment and more farmer-friendly. Working with a strain of P. includens that has not been exposed to pesticides before, we would like to explore the ecological scenarios in which resistance is likely to evolve.

Questions we will address:
1) How quickly can resistance to a pesticide (Spinosad) evolve?
2) Aside from resistance to the pesticide, how else is the caterpillar affected by each pesticide exposure. For example, do they eat more, eat less, produce fewer offspring, etc.?

Significance

The effects of this work have broad reaching implications for multiple disciplines, including economics, medicine and environmental science which span local, national and global scales. Pesticide use has a tremendous effect on our society. Billions of dollars yearly are lost to pests or spent trying to control them, not only in Georgia and North America, but worldwide. The list of human health effects of pesticide exposure continues to expand (respiratory effects, developmental effects, cardiac effects, etc.), fueling the ever growing organic market, and global environmental degradation of soil quality, water quality and air quality is at the forefront of environmental science research. Understanding the scenarios under which pesticide resistance evolves is key to controlling the impact of pesticides on our daily lives.

Goals and Products

The products from this research will include a poster presentation for the North Georgia Research Conference and a presentation for Georgia Academy of Science, both in Spring 2014. We also plan to develop an educational brochure about the multiple effects of pesticide resistance for University/Community level distribution. This work will be carried out by our current independent research student, Andrea Wilson. Upon completion of her Independent Study this semester, this FUSE project will allow her to carry out, from conception
to final product, her own research questions. This will advance her development as a critically thinking scientist and provide data that will spawn additional research directions for future undergraduate students.

**Undergraduate involvement in project**

This project was envisioned by Andrea Wilson, a junior Biology Major, who has been active in our research since Fall 2012 when we started. However, the time required to successfully complete this project in a timely manner is outside of the scope of what is possible during the school year. We are excited for the possibility of having this project funding because it will give her the opportunity to explore her own research interests. Dr. Barding and Dr. Smith will offer guidance and oversight to Andrea as she works through this project, but we are eager to give her the lead. Andrea will engage in all aspects of the experiment, including experimental design, caterpillar rearing, pesticide application, pesticide effect data collection, data analysis, and reporting results. We have every confidence that she will be fully successful because she has already shown proficiency in conducting independent research as a part of our research team both as a volunteer (Fall 2012) and Independent Study student (Spring 2013). In this time she has also emerged as the leader of our undergraduate group, technically, creatively and organizationally. She is currently training and coordinating the efforts of 2 other talented undergraduates.

**Plan for faculty mentorship**

While clearly, Andrea will creatively and practically lead this project, we are well aware that she is still developing her skills as a researcher and will face challenges. Making this a successful and positive experience for everyone will require thoughtful mentoring. We will mentor Andrea through a series of informal daily meetings and once-weekly formal meetings.

*Informal Daily Meetings:* These meetings will allow us to address any questions or difficulties Andrea is facing that may arise once the research is initiated. Daily contact will allow us to provide timely feedback given that the FUSE program is only 8 weeks long. Dr. Barding is teaching a class during the first short summer session, so Dr. Smith will be the primary point of contact at this time. Dr. Smith is teaching a class during the second short session, so Dr. Barding will be the primary point of contact for the later weeks of the project. We anticipate no problems with this arrangement because we have always collaborated on our research at UNG. Students are comfortable seeking answers from both of us, and our frequent communication ensures that both of us remain up to date on research progress.

*Formal weekly meetings.* Formal weekly meetings with Dr. Barding, Dr. Smith and Andrea will focus on helping Andrea develop as a scientist so that this is a truly immersive experience. We anticipate that at the beginning of the semester our formal meetings will focus on reading primary literature, developing methods, and oversight of rearing the caterpillars. During the middle of semester we will focus on carrying out the experiment, methods of data analysis, troubleshooting research, and developing an educational brochure about the effects of pesticide resistance. At the end of the semester the focus will include actual analysis of Andrea's data and development of a poster and oral presentation for dissemination of her work.
III. Budget and Timeline

Projected Timeline

Prior to FUSE – Andrea will be completing her independent study during the Spring 2013 semester, the goals of which are to produce a research proposal and carry out preliminary experiments to investigate the effects of natural vs artificial diets on the growth and development of *P. includens*. This research will help to prepare her for the FUSE project and ensure that we have all of the tools in place to successfully carry out the proposed experiments.

Week 1
Review of primary literature and discussion of final paper written during Andrea’s SP13 Independent Study, including methodology limitations, possible rearing improvements, and pertinent data analysis. Finalization of research methods and creation of lab notebook for data management. Start identifying information to include in brochure about pesticide resistance

Week 2-6
Begin experiments; application of pesticide (Spinosad), data collection, review of lab notebook. Troubleshoot any experimental problems that arise. Conceptualize brochure about pesticide resistance, and identify appropriate outlets for brochure distribution at the University and community levels.

Week 7
Final collection and analyses of data, review lab notebook, create educational brochure about the multiple effects of pesticide resistance.

Week 8
Development of poster and presentation, including appropriate visual representation of methods and data analysis (i.e., graphs, tables, photos of methods, etc.), practice presentation, finalize pesticide resistance brochure

Post FUSE project – Andrea will present a poster at the North Georgia Research Conference and Georgia Academy of Science, both in Spring 2014, distribute brochure to appropriate outlets.

Budget

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<th>Category</th>
<th>Purpose</th>
<th>Amount</th>
<th>Price</th>
<th>Total</th>
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<tr>
<td>Caterpillar Diet</td>
<td><em>Artificial diet for feeding caterpillars</em></td>
<td>2X 10 liters</td>
<td>51.10/10 liters</td>
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<td>Petri dishes</td>
<td><em>Experimental chambers for pesticide exposure</em></td>
<td>1 case</td>
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<td>Greenhouse supplies</td>
<td><em>Seeds, soil, pots</em></td>
<td><em>Ad lib</em></td>
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<td>Deli containers</td>
<td><em>Moth housing</em></td>
<td>1 case (500 containers)</td>
<td>97.77/case</td>
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<td>Spinosad Concentrate (pesticide)</td>
<td><em>Pesticide application</em></td>
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<td>19.95/Quart</td>
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<td>TOTAL</td>
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<td><strong>447.58</strong></td>
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IV. Certifications
We are happy to provide the original signed copy upon request.

Faculty Certification
I hereby certify that Dr. Erin Barding and Dr. Margaret Smith will teach no more than 8 course hours during each summer session spanned by the FUSE program. Dr. Erin Barding and Dr. Margaret Smith are committed to mentoring Andrea Wilson on a continual basis during the period of the FUSE program.

Faculty Member (Dr. Erin Barding): ________________________________

Faculty Member (Dr. Margaret Smith): ________________________________

Department Head (Dr. Nancy Dalman): ________________________________

Student Certification
I hereby certify that I, Andrea Wilson, will commit at least 40 hours per week to the scholarly project describe in this application. I also certify that I am not enrolled in more than 4 course hours during each summer session spanned by FUSE. I am aware that failure to comply with these two requirements may result in the forfeiture of my summer stipend.

Student (Andrea Wilson): ________________________________
Works Cited


