Costs and Benefits of Shelter-Sharing in Tropical Caterpillars

ACS FAC Renewal Final Report

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Research Summary

Many species of herbivorous insects such as butterfly and moth caterpillars feed within shelters that they make by tying together leaf material with silk. While this shelter-feeding behavior may reduce predation by some enemies, caterpillars in shelters are still attacked by parasitoids; insects that consume living caterpillars by feeding within their bodies until they eventually emerge as adults and kill their host. Some caterpillars share their shelters with several members of their own species, which could lead to higher attraction rates of parasitoids to these shelters. Summer research with students tested the hypothesis that caterpillars at higher densities in shelters would be parasitized at a higher rate than those that occupy shelters alone. Contrary to our expectations, there was no consistent increase in parasitism rates among 216 field-collected caterpillars occurring in groups of 1, 2, or 3 per shelter. We further tested the hypothesis with an experiment where we made artificial shelters on 82 plants and stocked them with either one (n = 43) or three (n = 39) caterpillars per shelter. Similar to the results of the field survey, we found no difference in parasitism rates between these two treatments. Therefore, these results did not support our prediction of a cost of shelter sharing in these caterpillars. Indeed, they suggest that if there is a cost due to increased parasitism rates in this species it is a minimal one.

Goals and Objectives

I conducted the research for this project from 6/17/2008 – 8/15/2008 at the La Selva Biological Station in Heredia province, Costa Rica. The research had five primary objectives: 1) provide me an opportunity to mentor a student with interests in tropical research and environmental studies, 2) allow me to establish collaborations with other scientists in my field and enhance my research productivity and professional development, 3) contribute basic scientific knowledge that will be presented at regional and national meetings and submitted to peer-reviewed journals, 4) enhance my research productivity and professional development by allowing me to pursue research begun last summer at this location and with these insects, and 5) broaden my experience in tropical field ecology and be exposed to new research questions and increased biodiversity.

Goal 1: Student mentoring

The original goal was to mentor one student with interests in tropical biology, but Dr. Megan Gibbons (of Birmingham-Southern College) and I were fortunate enough to have a total of 5

students join us for the summer. I interacted extensively with two rising senior Biology students, Rebekah Pine and Scott Shashy. I also worked closely with three other students (Kimmie Farris, Thiago Quieroz, and Ron MacBeth). All of these students assisted Dr. Gibbons and myself with field research and also developed their own independently-conducted research projects under the guidance of myself and Dr. Gibbons. We held weekly paper discussions throughout the summer with each student leading two discussions related to their research projects. We also had students submit project proposals at the beginning of the summer to give them experience in the full process of conducting research. This experience will be reinforced during their senior research projects in Biology. All of the students presented their summer research projects at the College's annual poster session for science summer student research.

The summer provided numerous opportunities for all of us to discuss the scientific process, field research, the process of developing specific research goals and methods, and the excitement and challenges of working in the tropics. We also encouraged the students to participate in other research projects that students from other colleges and universities were conducting. Over the course of the summer, our students participated in field research projects with numerous other graduate students and faculty, which provided a firsthand exposure to research questions in tropical ecology. I expect that, because of this exposure to field research, these students are uniquely prepared for conducting their senior capstone research projects.

Goal 2: Professional collaborations

La Selva Biological Station, where this research was conducted, hosts hundreds of researchers throughout the year, and one of the peak activity times is during the time that we were at the station (June-August). Therefore, I was able to interact with several graduate student and faculty researchers during the summer. I worked on projects with two other faculty during the course of the summer (Grant Gentry of Samford University and Victor Townsend of Virginia Wesleyan College). I also began a new collaborative research project with a graduate student from Duke University (Arietta Fleming-Davies).

The project with Townsend also involved Carlos Vieques, a research scientist at the Costa Rican National Institute of Biodiversity (INBio). The three of us are currently writing a grant proposal to be submitted to the National Geographic Foundation on research begun this summer. I

expect that these collaborations will open up additional research opportunities for Birmingham-Southern College (BSC) undergraduate students in future summers at La Selva Biological Station.

Goals 3 & 4: Conduct research & present data

For this third objective, I continued two projects that I had begun last summer. The first project (and the main focus of my research) involved a study of shelter building caterpillars and their natural enemies. I continued to gather data on this system to add to last year's results. For this study, the students and I collected and reared caterpillars of *Desmia* sp. moths (this species has yet to be definitively identified). These caterpillars build shelters on plants by folding leaves and tying them together with silk. They then feed within these shelters at densities of 1 – 8 caterpillars per shelter. Despite feeding in these shelters, they are often attacked by parasitoids, which are flies or wasps whose larvae develop in living caterpillar hosts following oviposition by the female parasitoid. Because others have found that gregarious species of shelter-building caterpillars are more frequently attacked by parasitoids than solitary species, our experiments over the summer tested the hypothesis that caterpillars at higher densities would be parasitized at a higher rate than those that occupy shelters alone.

We tested this hypothesis in two ways. First, we collected 216 caterpillars that occurred naturally at densities of 1, 2, or 3 caterpillars per shelter. We then supplied them enough plant material for them to continue development until metamorphosis. For each caterpillar, we then recorded whether a parasitoid adult emerged or whether the adult moth developed normally from the pupa. Although the three categories differed in parasitism rates (Chi-squared = 14.59, DF = 2, P = 0.00068), greater caterpillar densities did not lead to consistently higher parasitism rates (closed bars in Figure 1). In fact, the lowest parasitism rate occurred in the middle density category of two caterpillars per shelter. There were no differences between the highest and lowest categories (1 vs. 3; Chi-Squared = 1.47, DF = 1, P= 0.22).

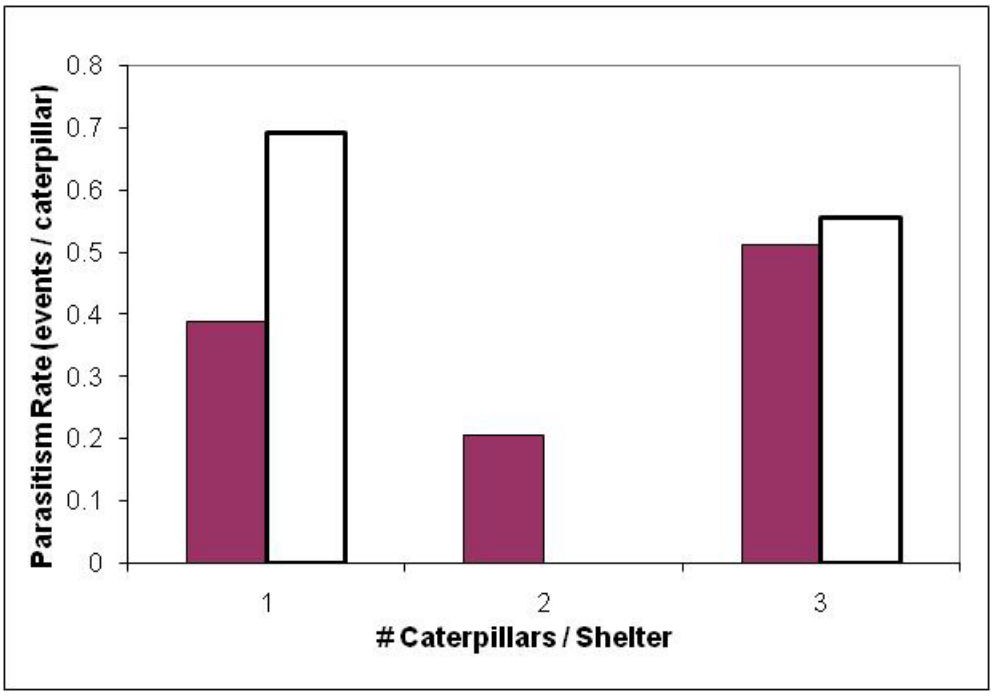

Figure 1. Parasitism rates of *Desmia* caterpillars in 2008. Solid bars represent caterpillars collected from the field that naturally occurred as 1 (n = 108), 2 (n = 63), or 3 (n = 45) caterpillars per shelter. Open bars represent caterpillars recovered from artificial shelters that were experimentally stocked with either 1 (n = 18) or 3 (n = 53) caterpillars per shelter.

As an additional test of the hypothesis, we conducted an experiment where we manipulated the number of caterpillars in an artificially constructed shelter. We established 82 experimental plants with one artificial shelter apiece, and either one (n = 43) or three (n = 39) caterpillars per shelter. We allowed the caterpillars to be exposed to parasitoids for 5 – 7 days, and then brought them back to assess parasitism rates as in the previous experiment.

We had a very low recovery rate of caterpillars in this experiment. Of the 82 shelters that we placed in the field, we were able to recover caterpillars in 49% of the cases (n = 40). Therefore, we only recovered 71 caterpillars out of the total of 160 we set out in the experimental shelters (caterpillar recovery = 44%). We did not detect a difference in the number of parasitized caterpillars in the two treatments (Chi-squared = 0.23, DF = 1, P= 0.631). In fact, there was a trend for solitary caterpillars to be parasitized at a higher rate than those stocked at three per shelter (open bars in Figure 1).

The second project was a continuation of a study begun by a BSC student (Whitney Brackin) last summer. This project was a collaboration with Rebekah Pine, Scott Shashy, and Dr. Victor Townsend. The students and I spent about 75 person hours searching for species of harvestmen (daddy long-legs) from seven different habitat types over the summer, yielding 25 total species. One of these species is undescribed, or previously unknown to science. The four of us presented these results at the summer student research symposium at BSC on 9/2/08. We are still analyzing the data from this research, and we hope to submit the manuscript to a peer-reviewed journal in the spring. Dr. Townsend and I are preparing to submit a proposal to the National Geographic Society to pursue this work. The students will present their results at the Latin American Studies Conference at BSC and also at the Association of Southeastern Biologists meeting in Birmingham in April, 2009.

Goal 5: Broaden experience & impact teaching

I am currently teaching two sections of Evolutionary Ecology, a course with considerable ecological content. I have already integrated examples and photos from the past two summers into my lectures and will continue to do so. In addition, I plan on integrating the techniques I learned over the summer for manipulating caterpillars and their natural enemies into field labs for future courses and research opportunities for senior student projects.

Future Directions

I learned a considerable amount while conducting these experiments, and this experience will be helpful in continuing this research in the future. One of the most important lessons learned over the summer was that the questions I was addressing required considerably more effort in the field than I had anticipated. The low recovery rate of caterpillars set out in the field reduced our realized sample size by over half. Furthermore, I had hoped to establish a breeding colony of *Desmia* moths that would supply me with hundreds of small caterpillars to use for research. Unfortunately, the adult moths never reproduced in captivity, which meant that I had to collect all of the caterpillars from the field for these experiments. This further reduced the sample size of the experiment and limited the conclusions from this research. In the future, I will either switch to another study species that can be cultivated in captivity or address a simpler question that requires

smaller numbers of caterpillars. Another alternative would be to repeat this experiment for several years and combine all data into the final analysis.

While the conclusions from the experiments are limited at this time, I nonetheless feel that this summer was a success. Our students gained valuable experience in field research, and also made considerable progress on ideas for their senior research projects. We also learned that it was feasible to take 5 students to this research station in Costa Rica for research for two months. In the future, we intend to apply for funding through BSC or the ACS to develop a summer research course in tropical ecology. This course will be a valuable opportunity for our students to gain first-hand experience doing field research for an extended period of time. BSC has made an institutional commitment to hands-on learning and mentoring by requiring that all Biology majors must complete a 1-year research project under the direction of one faculty member. Therefore, we also plan on offering these senior research experiences in Costa Rica in the future.

Evaluation and Dissemination

The results of both of these summer research projects (caterpillar parasitism and harvestmen survey) will soon be posted on my faculty web site and will be supplied to the ACS for posting at the ACS site (www.colleges.org). My original goal was to publish my summer research in a national peer-reviewed journal. Unfortunately, as indicated above, I do not think that the parasitism data are publishable at this time. Because of low sample sizes, I believe that at least one other season of research on this question is necessary. However, I and the students plan on presenting the preliminary results of both studies at the Association of Southeastern Biologists meeting (to be held in Birminham, AL in 2009).