EARTHWATCH INSTITUTE FIELD REPORT

SECTION I: UNEP- WCMC WEBLINK INFORMATION

Project Title: Forest Caterpillars

Principal Investigator: Lee Dyer

Position/Affiliations: Associate Professor, Tulane University

Research Sites and Local Management Status:

Napo, Ecuador, -0.583, -76.13, Biological Reserve, National Park
Sarapiqui, Costa Rica, 10.4, -82.0, Biological Reserve, National Park
Arizona, USA, 31.88, -109.2, Biological Reserve, National Forest

Scientific names of primary species being studied (if appropriate):
Lepidoptera, Hymenoptera, Diptera, Angiosperms

Key Research Objectives:

- What affects diversity and abundance of caterpillars and parasitoids in natural forests and adjacent agriculture (banana and alfalfa)?
- What parasitoids might be good candidates for biological control in banana plantations and alfalfa fields?
- How do variation in precipitation and temperature affect levels of parasitism (and subsequently affect caterpillar densities)?

Data Collection and Results

Climatic unpredictability and parasitism of caterpillars: implications of global warming

We quantified parasitism at our new research sites in Ecuador and Arizona and continued to refine our data for Costa Rica. Our most significant finding is relevant to the hypothesis that insect outbreaks will increase in frequency and intensity with projected changes in global climate. This outbreak hypothesis is based on predictions from the dynamics of single populations at one trophic level, yet complex interactions within the larger community are also likely to be influenced by climate change. Our research program utilized a broad geographic view of this understudied issue by combining our data with our collaborators' rearing efforts and comparing plant-caterpillar-parasitoid interactions across geographic and climatic gradients in the Americas. Preliminary results from fourteen long-term databases uncovered three important relationships between climatic variability and parasitism of caterpillar populations. First, overall parasitism frequency decreases as climatic variability increases (Figure 1). Second, because there were no significant effects of latitude and temperature, this general pattern cannot be explained by tropical-temperate disparities in parasitism pressure. Finally, the dominant contribution to this pattern by more specialized wasps suggests climatic variability primarily affects tracking of host populations by these parasitoids. Because of their natural and managed roles in the regulation of insect herbivore populations, these relationships imply an increase in the frequency and intensity of

caterpillar outbreaks as climates become more variable. Given the dramatic economic and environmental impacts of herbivore outbreaks in terrestrial ecosystems, the effects of climate change via disruption of enemy-herbivore dynamics may be highly significant.

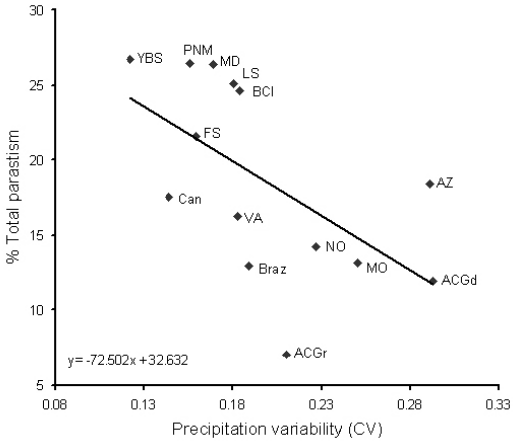

Figure 1. A linear regression of total parasitism rates of caterpillars from fourteen caterpillar rearing programs against year-to-year variance in precipitation (CV; $R^2 = 0.43$). Letter codes correspond to sites of rearing studies; AZ = Southeast Arizona, USA; ACGd = Guanacaste Conservation Area, Costa Rica, dry forest; ACGr = rain forest; LS = La Selva Biological Station, Costa Rica; YBS = Yanayacu Biological Station, Ecuador; NO = Southeast Louisiana, USA; Braz = Reserva Ecológica do IBGE, Brazil; BCI = Barro Coloardo Island, Panama; PNM = Parque Nacional Metropolitana, Panama; FS = Fort Sherman, Panama; Can = Southern Ontario, Canada; MD = Maryland, USA; MO = Southern Missouri, USA; VA = Virginia and West Virginia, USA.

Predicting Caterpillar Parasitism in Banana Plantations

We used Earthwatch parasitism data to link ecological theory to the biological control of insect pests in banana plantations. Through our established predictive approach, ecological data on plant-caterpillar-parasitoid interactions from natural systems were used to formulate simple recommendations for biological control in banana plantations. The specific goals were (1) to determine the most effective parasitoid enemies for biological control of lepidopteran larvae in banana plantations and (2) to examine the impact of nematicides on enemy populations. To assess percent parasitism,we reared 1,121 lepidopteran larvae collected from six plantations managed under two nematicide regimens. Attack by parasitoids in the families Tachinidae (Diptera), Braconidae, Eulophidae, and Chalcididae (Hymenoptera) closely paralleled rates reported for species with similar characteristics at our Earthwatch site at La Selva, and statistical models predicted the relative importance of these parasitoids as sources of mortality. We found that tachinid flies were the most important source of early instar larval parasitism in banana plantations, and their importance increased with more intensive nematicide applications. The statistical models that we derived from data at La Selva were useful in predicting which parasitoids would be important in banana and which larval characteristics they would preferentially attack (Figure 2). This approach could be used in other managed ecosystems (e.g., near our sites in Ecuador and Arizona) where the identification of effective biological control agents is needed.

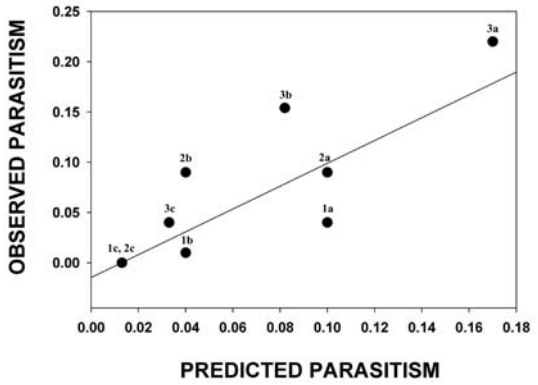

Figure 2. Regression of actual parasitism values (proportion of hosts parasitized) by tachinids, braconids, and eulophids against levels of parasitism predicted from models. Predictions were derived by applying logit models to data from La Selva, using characteristics unique to each of three focal caterpillar species as predictor variables. For each caterpillar species, levels of parasitism were predicted for each of the three parasitoid families detected in plantations, yielding 9 comparisons. For label legends: 1 = *C. memnon*, 2 = *O. tamarindi*, 3 = *A. viridis*; a = Tachinidae, b = Braconidae, c = Eulophidae.

Significance/Benefits of Research

Diversity and natural history

Our most significant accomplishment is the compilation of natural history data related to approximately 2500 species of caterpillars, plants, and parasitoids. We share this natural history information with locals and scientists alike (refer to the list of talks and publications), including talks in Spanish to Costa Rican and Ecuadorian students, naturalists, and local workers; the local talks have increased awareness and respect for insect diversity. Many of the naturalist guides at our research sites now point out caterpillars in their tourist walks and discuss the role they play in the forest. We also share these data with anyone who has internet access by publishing it on caterpillar web pages at www.caterpillars.org. The web pages are currently undergoing major improvements and should be a very useful tool for managing and studying biodiversity for many years to come.

Sustainable agriculture

Managers of banana plantations and other agricultural systems who are attempting to control pests without using pesticides will benefit from increased knowledge of the parasitoid community. First, we discovered at least 10 new species of parasitoids (that are still being treated by taxonomists) in the families Braconidae and Tachinidae, all of which are potentially important biological control agents. Second, our modeling approach identified the most important biological control agents in banana plantations under different pesticide management, which allows plantation owners to manage for caterpillar pests without resorting to harmful insecticides.

Sustainable employment in the rainforest

Although it is not a direct benefit from the research, our Earthwatch project benefits the local communities by supporting the research stations and by continuing collaborations with local naturalists and scientists. Field stations generally benefit the local community

by providing excellent employment opportunities that are not destructive to the forest and by boosting the local economy. At the Costa Rica site, we continue to provide long-term employment to local naturalists, Gerardo Vega and Humberto Garcia; at the Ecuador site, we have provided long-term employment to Marco and Santiago Gualinga. We plan to continue hiring as many local naturalists as possible, depending on continued funding from other sources.

Environmental education

Finally, our work has directly benefited the educational community because many volunteers have been school teachers and have incorporated ideas learned from this project into their classes. It has indirectly benefited the educational community because the research addresses basic theoretical questions in ecology. One of the most important issues to which our Earthwatch project has contributed is the idea of "trophic cascades." Theory predicts that the effects of predators and parasitoids on plant biomass and diversity should not be great in complex systems such as rainforests, but we have demonstrated that the enemies of caterpillars significantly enhance plant biomass and diversity by killing caterpillars. This means that the consequences of tropical predator extinctions are more severe than previously thought, and predators of all sizes and all predatory guilds (i.e. including parasitoids) should be a major focus for conservation efforts.

Dissemination of Results *(all publications below are available in pdf format at: http://www.tulane.edu/~ldyer/papers.htm)*

Peer reviewed articles and book chapters

Stireman, J.O. III, Dyer, L.A., and R.M. Matlock. *In press*. Top-down forces in managed versus unmanaged habitats. In: Barbosa, P. and I. Castellanos (eds.). Ecology of Predator-Prey Interactions. Oxford University Press.

Letourneau, D.K. and L.A. Dyer. *In press*. Multi-trophic interactions and biodiversity: beetles, ants, caterpillars, and plants.In: Hartley, S. (ed.). Biotic Interactions in the Tropics: Their Role in the Maintenance of Species Diversity. Academic Press.

Irschick, D., Dyer, L.A., and T. Sherry. *In press*. Phylogenetic methods for studying specialization. Oikos.

Dyer, L.A., Matlock, R.M., Cherzad, D., and R. O'Malley. 2005. Predicting successful biological control in banana plantations. Environmental Entomology 34:403-409.

Dyer, L.A., Dodson, C.D., Letourneau, D.K., Tobler, M.A., Hsu, A., and J.O. Stireman III. 2004. Ecological causes and consequences of variation in defensive chemistry of a neotropical shrub. Ecology 2795-2803.

Letourneau, D.K., Dyer, L.A., and G. Vega. 2004. Indirect effects of top predator on rain forest understory plant community. Ecology 85:2144-2152.

Dyer, L.A., Gentry, G. and M. Tobler. 2004. Fitness consequences of herbivory: impacts on asexual reproduction of tropical rainforest understory plants. Biotropica 36:68-73.

Books

Dyer, L.A. and A.N. Palmer. 2004. *Piper*. A model genus for studies of evolution, chemical ecology, and trophic interactions. Kluwer Academic Publishers, Boston.

Presentations

Eminent Ecologist Lecture Series - University of Pittsburgh, 2004
Organization for Tropical Studies, Costa Rica, 2004
Southwest Research Station, 2004
Oklahoma University, 2004
Indiana University, 2005
Ecological Society of America, Annual Meetings, 2004