Introduction

Kleptoparasitism is a behavior in which an organism steals previously prepared resources from another organism (Brockman and Bernard 1979). This preparation can include search behavior or handling of a resource; such as wrapping and external digestion in spiders, opening shells in clam feeding birds, or brood ball preparation in dung beetles (Brockman 1979, Iyengar 2008). An initial attempt was made by Brockman and Bernard (1979) to set a series of criteria (in avian systems) that were required to facilitate the evolution of kleptoparasitism and further clarification was presented in a subsequent study by Iyengar (2008).

Using the excellent previous research my current research group at the University of North Carolina Greensboro has built a general model of kleptoparasitic behavior in order to aid in the differentiation of this specialized system from that of parasites (Fitzgerald *et al* unpublished). We looked at this behavior in a new way through the application of cost-benefit analysis. Kleptoparasitic behavior is often difficult to implicitly classify because it is much more difficult to quantify the loss of a non-specific resource. Oftentimes we may not be able to look at a single resource; instead we must focus on the effect of a number of stolen resource items either on an individual or a population level. Still more difficult perhaps, the stolen resource is often not a food item, but a preparation for brood-rearing, and the real loss may be the time that must be spent guarding that brood ball because of the possibility of kleptoparasitic attack. In these cases the loss to the host (and gain for the kleptoparasite) is not the resource itself, but rather the skilled, time- or energy-consuming work that is involved in catching, transporting, building, or other preparation of the food or the resource. Using a cost-benefit approach to studying the behavior allowed for development of specific criteria for the definition of the loss and gain in a system that can be used across all taxa.

Proposed Topic of Study

I propose to continue the use of cost-benefit analysis in the study of kleptoparasitic behavior in my graduate work. However, my analysis will broaden the focus of my modeling to work with a greater sample of kleptoparasitic organisms allowing experimentation and empirical studies across many taxa, promoting a broad view of the biotic and abiotic environment that can trigger stealing behavior in an population as well as the specific details of organism interactions that may promote evolution of the behavior.

Hypothesis 1: A single game theoretic model can be used across taxa to compare and contrast significance of behavioral and ecological variables in the evolution of kleptoparasitism

H1a. A game theoretic model can only be used across a single taxon to compare and contrast significant variables in the evolution of kleptoparasitism

H1b. No general model can describe variables that promote the evolution of kleptoparasitic behavior across taxa

Research Plan

To begin a study of a specific organism, it will be necessary to gather previous research of the system and piece together information in order to build a rudimentary model. Upon development, that model will be used to determine variables that have a high level of significance to the evolution of the behavior. Based on the specific variables used in the model, it will then be possible to develop strong hypotheses and test variables with a directed approach using standard field and laboratory experimentation techniques. Returning to the model at this point, those factors found to be experimentally significant, as well as any new findings, will be developed and polished giving a close approximation of the costs to host and kleptoparasite.

After a series of these models are developed using similar techniques and a cost-benefit approach, the existing general model of my current research group will be used to test the fit of collected data to the general biological and mathematical model of kleptoparasitism.

My work in this particular study has already begun, as I have recently spent time developing a simple model of stealing behavior among spiders in the lifelong nutritional kleptoparasite A*rgyrodes* on their host, *Nephila clavipes* (Fitzgerald and Rychtar unpublished). The energetic gain for *Argyrodes* in this system is clear, as web-building is energetically costly. Our model focuses instead on the energy loss to the host because, while the host is a great deal larger than the thief in this case, a number of kleptoparasites can congregate on a single web, which can decrease the food consumption rate of the host, therefore decreasing fitness.

This spider system will be the first on which I will attempt field experimentation in graduate study, in order to determine specific fitness loss to a host spider with an increasing number of kleptoparasites. Experimental variables would include number of kleptoparasite individuals per web, number of food items caught, number of food items stolen, number of egg sacs built per time period, number of surviving brood, individual survival, mating instances, relocation and rebuilding of the web, and the timing intervals of all relevant aspects of kleptoparasitic behavior within a 24 hour time period. In addition, ecological variables that would impact the density of kleptoparasites on a web would be measured, specifically microclimate and microhabitat characteristics. Using experimentation techniques to determine fitness loss and gain (which impacts the evolution of a behavior) and comparing the relationship between "choice" behavior in our model and gathered data, the significance of specific variable can be determined.

Completion of this sequence would then be repeated with a number of kleptoparasitic systems in order to develop a more cogent model of selection pressures leading to the evolution of kleptoparasitism in a number of populations. Comparative analysis of the significance of variables in a great number of systems would be possible at this point to ascertain relationships across the spectrum of organisms exhibiting this behavior.

Anticipated Results and Greater Impact

I believe that using similar experimentation techniques will allow development of a fluid understanding of the evolution of kleptoparasitic behavior. Each system has an individual answer to the question of evolution, however, exploration of similarities and differences across taxa can grant guidance and increased depth to studies from each taxonomic group.

Typically in biology, a model is developed only after experimentation is concluded; however, taking advantage of the interplay between mathematics and biology is a way to strengthen both approaches. The use of my unique resources, as a biological graduate researcher in a program with a dedicated history of behavioral research, along with my continued collaboration with a group of outstanding mathematicians in the field of kleptoparasitism, will strengthen the bond of mathematical and biological research in my field as well as providing a greater understanding of a relatively unknown behavior.

Citations

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