

UNIVERSITY HONORS PROGRAM

SENIOR PROJECT - APPROVAL

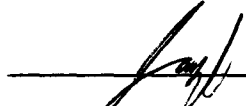
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Faculty Mentor: Dr. Jake Weltzin

PROJECT TITLE: Competition and Invasion in a Microcosmic
Setting

I have reviewed this completed senior honors thesis with this student and certify that it is a project commensurate with honors level undergraduate research in this field.

Signed:  Jake F. Weltzin, Faculty Mentor

Date: 4 May 2004

Comments (Optional):

Austin Faulkner

Senior Honors Project:

Competition and Invasion in a Microcosmic Setting

Spring 2004

Abstract

Students: Austin Faulkner, Bill Holmes, Jacob Kendrick, Jeff Lowder, Elizabeth Martin,
and Alex Perkins

Faculty Sponsors: Suzanne Lenhart, Louis Gross, Jake Weltzin, and Jim Drake

Abstract: Single species experiments with two species from genera *Colpidium* and *Paramecium*, and analysis of data were completed to estimate growth rates and carrying capacities. The underlying model for each species is a differential equation with logistic growth. Experimental data was used to estimate carrying capacity (K) and growth rate (r) of the two species. Next, the two species were grown in competition; that data was used to determine competition coefficients for the two species. This data will be used in the next phase of the experiment, which is to include a spatial component. We are currently in the process of determining migration rates of the two species; once the rates have been determined experimentally we will begin the next phase. We hope to prove that propagule pressure will affect invasibility of a system that includes migration.

Introduction:

For the past year I have been involved in an undergraduate research experience. The goal of the research experience has been the study and creation of Spatial Distribution Models of Invasive species; the research is paid for through a grant provided by the NSF. The abstract above, along with the PowerPoint presentation, details the early stages of one phase of the research: competition on a microcosmic scale. In order to understand how invasion affects a system, it is important to understand the effects of competition between the integrated species. With that in mind, a series of experiments were designed to study competition between two microorganisms: *Colpidium striatum* and *Paramecium Aurelia*. I was involved in the design, creation, data collection, and analysis stages of the experiments.

Methods:

Colpidium striatum and *Paramecium aurelia* were chosen as the two initial species because they have similar life spans, prey solely on bacteria (they will not eat themselves or each other), and are easily identifiable.

Project One: The first phase of the experiment involved independent growth of the two species to determine growth rate (r) and carrying capacity (K) for each. A multiple replicate system of three densities (one, five and ten individuals per milliliter in 100 mL jars) and three replicates each was used to reduce error in the final rates. 0.2 mL samples were taken each day and the individuals present in that sample counted. Nutrient solution was used to replace the sample removed from each jar. Final numbers of each replicate were averaged together and used to compute (r) and (K) for the two species (for

results, see table 1). Models, assuming basic logistic growth, were made using the data. This information was used for the next set of experiments, competition.

Project 2: During this stage of experimentation a four replicate system was used in order to further reduce error. Cultures of *Colpidium striatum* and *Paramecium aurelia* were grown in monoculture (as a control) and competition with three starting densities: 9:1, 5:5 and 1:9 ratios (in individuals per mL) of *Colpidium* to *Paramecium*. The object of this set of experiments was to determine simple competition coefficients, as well as to determine if propagule pressure had an effect on species viability. Both organisms were grown and sampled on a daily basis, at approximately the same time each day. The data was then used to create ordinary differential equations (ODEs), which were solved and plotted along a timeline.

Results:

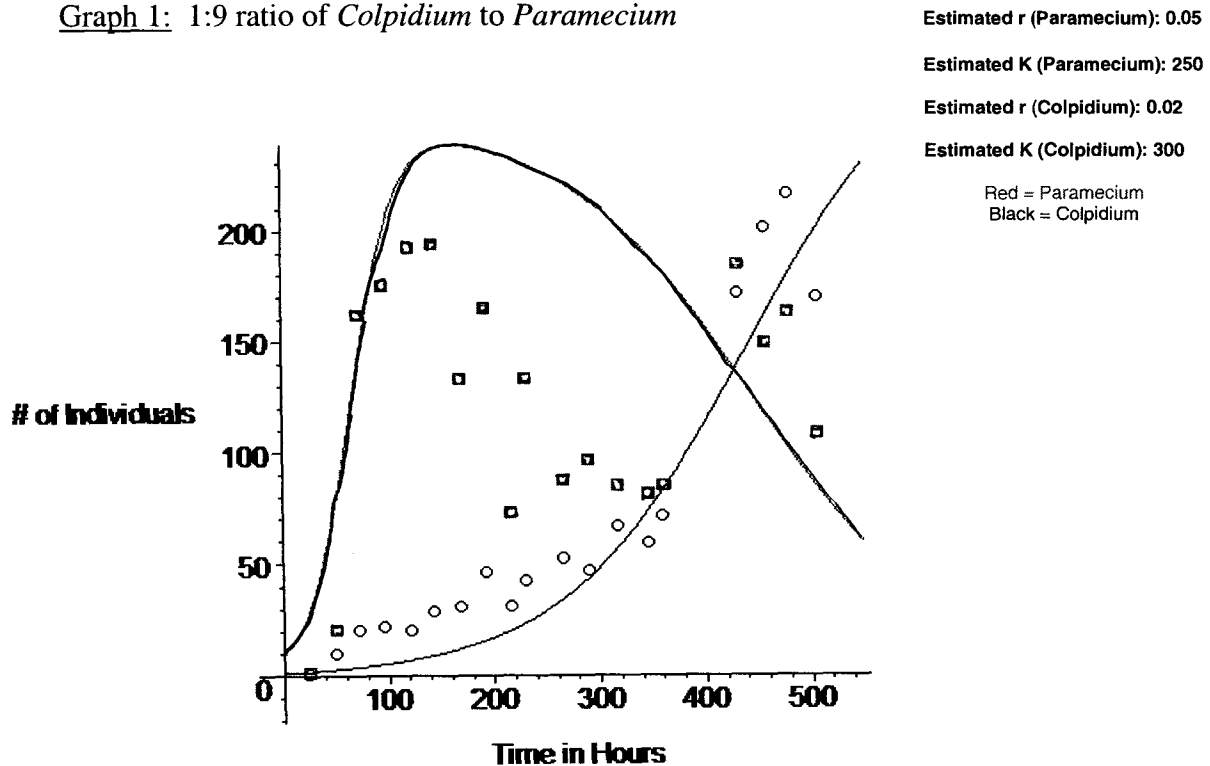
Analysis of the graphs led to the conclusion that *Colpidium* is a better competitor than *Paramecium*. The competition coefficients we assigned to the two organisms were 1.0 for *Colpidium* and 0.5 for *Paramecium*, meaning that *Colpidium striatum* has twice the competitive effects on *Paramecium aurelia* than it has on itself. In other words, each *Colpidium* is twice as effective at using resources, so every one present in a microcosm “counts” as two *Paramecium* as far as the *Paramecium* are concerned, and two *Paramecium* are necessary to give the equivalent effect of one *Colpidium*. Due to this fact, *Colpidium* was always able to out-compete *Paramecium*, despite the fact that they have a lower growth rate and take longer to reach carrying capacity (See Graphs 1, 2 and 3).

Contrary to our hypothesis, propagule pressure did not seem to change the final outcome of the competition; *Colpidium* always beat *Paramecium* eventually, with the former always driving the latter to extinction. Alternating the initial densities of the two species only seemed to delay the outcome, but was unable to change it. It is possible that extreme differences in initial density (i.e. ratios of 1000:1 *Paramecium* to *Colpidium*) could change the eventual outcome, but according to the specifics of this experiment it seems as if the only outcome of competition between these two species is extinction of *Paramecium aurelia*.

Table 1:

	Growth Rate (r)	Carrying Capacity (K)
<i>Colpidium</i>	0.02	300 individuals per mL
<i>Paramecium</i>	0.05	250 individuals per mL

Graph 1: 1:9 ratio of *Colpidium* to *Paramecium*



Graph 2: 5:5 ratio of *Colpidium* to *Paramecium*

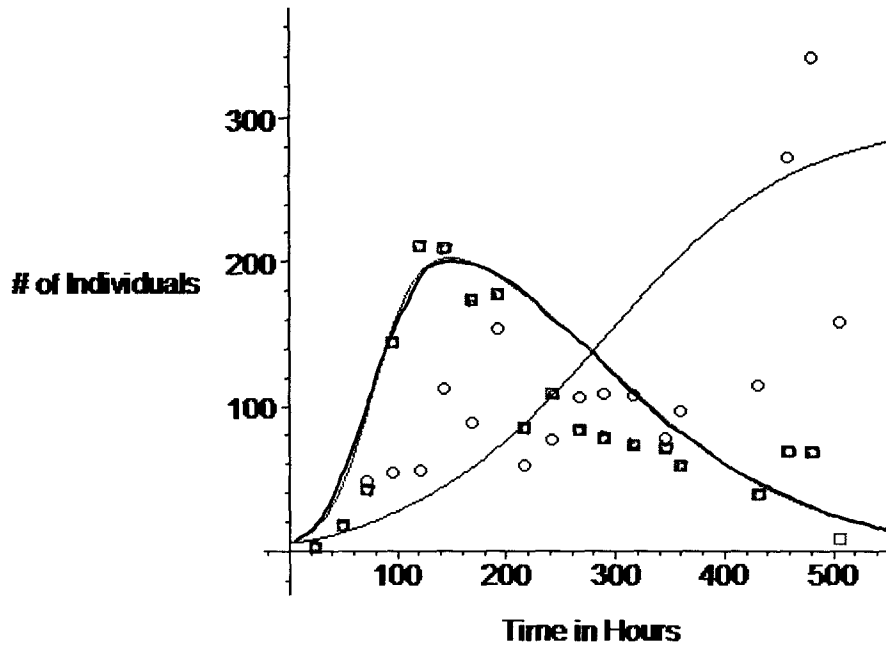
Estimated r (Paramecium): 0.05

Estimated K (Paramecium): 250

Estimated r (Colpidium): 0.02

Estimated K (Colpidium): 300

Red = Paramecium
Black = Colpidium



Graph 3: 9:1 ratio of *Colpidium* to *Paramecium*

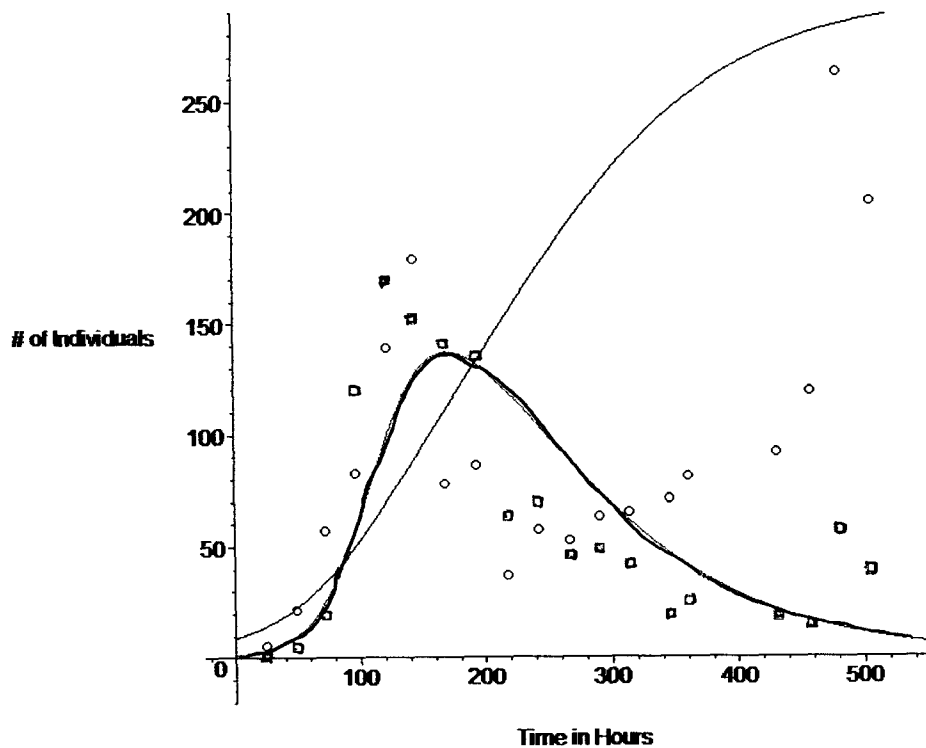
Estimated r (Paramecium): 0.05

Estimated K (Paramecium): 250

Estimated r (Colpidium): 0.02

Estimated K (Colpidium): 300

Red = Paramecium
Black = Colpidium



Discussion:

The initial question of the experiment was: How does propagule pressure effect invasion? During the course of the second competition experiment the question was answered, at least to some extent: even with ratios of 9:1, the inferior competitor (*Paramecium*) is unable to out-compete, or even coexist, with the superior competitor (*Colpidium*). Whether or not this situation would hold true with drastically different initial densities has yet to be determined, but future experiments in that direction may still be performed.

Thus far my involvement with this research has given me the opportunity to do personal research in a lab setting, and over the summer I will be able to introduce a field component to my research. I will also be attending a national conference sponsored by the Ecological Society of America (ESA) in Portland, Oregon. Working with students in the mathematical field has increased my understanding of mathematical approaches to biological problems as well. I feel that working on this project has helped me to learn more about my field of expertise while allowing me to interact with, and come to better understand, other approaches.