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BCOR 012

The effect of intraspecific competition on *Paramecium micronucleatrum* population growth.[1]

Abstract:[2]

Competition, the main driver of evolution, is a relationship not only between species of similar niches but also between individuals within the same species. This facet of interrelationships is called intraspecific competition and can have a significant impact on the success and growth of a population. This interaction, like all forms of competition, should be dependent on the density of the individuals involved[3]. In this experiment, intraspecific competition amongst populations of *Paramecium micronucleatrum* of two different densities were observed for 7 days in order to test the hypothesis that a denser population will experience more intraspecific competition and therefore have a lower growth rate and lower carrying capacity due to the lower amount of food available.[4] By counting the number of living *P. micronucleatrum* in a small sample of the populations daily for a week, we calculated the concentration of individuals per milliliter of culture. By using the equation of logistic growth $N_T = N_0e^{rt}$ and its natural log $\ln(N_T) = rt + \ln(N_0)$, it was possible to estimate the carrying capacity (K) and the growth rate (r) of each of these two populations[5]. Although the higher density population has a higher estimated carrying capacity than that of the lower density population, the reduced growth rate of the higher density population supports the hypothesis that the higher density population undergoes more extreme intraspecific competition. [6]

Introduction:[7]

According to Darwinian evolution, only the fittest of a species will survive. Limited resources such as food supply and space restrict populations from unlimited growth and spur the bettering of profitable adaptations.[8] This statement not only describes the relationship between

[1] Incomplete sentences are ok, but must effectively represent the study
[2] Having Less than 250 words is best. Includes 1-3 sentences from each section
[3] 3 sentences from introduction to provide context
[4] Hypothesis should be presented somewhere between the intro information and the results
[5] Optional to include numerical results, but important to distinguish the discussion/conclusions
[6] Interpretation of results and connection back to the larger context
[7] Introduction should provide context through background information on previous studies, introduce key terms used later, and lead to the statement of the hypothesis.
[8] Begin very broad and gradually narrow down to the experiment at hand

different species but also amongst individuals within the same species. This facet of interaction is called intraspecific competition[9], which forces individuals to fight for survival.

Intraspecific competition is a useful mechanism that stability controls a population's size in order to avoid its crashing . . .With intraspecific competition, not only does the size of a population stabilize at carrying capacity, but the most fit individuals are the most successful, ensuring the health of the future generations in that population.

Without limited resources there would be no competition; it is a response to external stress which threatens or limits an individual's success and longevity. . . Because the degree of competition is dependent on the limiting resources, population density should also play a role in determining the degree; as population density increases, the amount of resources per individual decreases, in turn increasing competition.

This process takes place over a long timescale however, and there are other effects of competition that occur in more observable and researchable scales. Population density and growth rates are closely in sync with the extremity of competition taking place within a population. A population experiencing no competition will have a timescale population graph resembling an exponential curve. A population experiencing a high level of competition will have a graph resembling a logistic or "S shaped" curve. [10]

In this experiment, two different concentrations of *Parameceum micronucleatrum* were observed over 7 days in order to discern the correlations between limited food availability (intraspecific competition) and the population's size over time.[11] The population with the higher concentration of individuals and smaller concentration of food will experience a higher degree of intraspecific competition and therefore show more limitations in growth rate than the other population type which has fewer individuals and more food. [12]

Methods:[13]

The methods used in this experiment were fairly simple. In order to isolate the specific impacts of intraspecific resource competition, two types of populations of *P. micronucleatrum*, a

[9] Define key terms early on.
[10] Chance to explain reasoning behind expectations using contextual information
[11] Brief summary of the experiment's methods
[12] Hypothesis: cause and effect of the manipulation of variables, can be expressed in 2 statements if needed
[13] Written in past active "we" and/or past passive voices. In paragraph form, not in a bulleted or numbered list. Do not fill with unnecessary details, but descriptive enough to replicate experiment.

small ciliated protist that filter feeds on bacteria, were observed. The first was a culture consisting of roughly 400 individuals. This was accomplished by adding 0.35 milliliters of to 19.65 milliliters of bacterial medium to bring the volume of the solution to 20 ml in a 50 ml sealable tube. The second population had roughly 800 individuals, created by combining 0.7 milliliters of 1100 individual/milliliter concentrated Paramecium stock to 19.3 milliliters of bacterial medium. The 800 population therefore has less food available per individual than the 400 population, increasing the intensity of intraspecific competition. [14]

There were 3 replicates of these two population concentrations each to ensure accuracy of observation, for a total of six 50 ml tubes which were not left sealed airtight to ensure that the *P. micronucleatrum* populations were not affected by lack of oxygen . . . A dissection microscope was used for the estimation of the count. Using this number and the volume of sample observed, the concentration of the population was calculated for uniform comparison. This was repeated once daily from Day 2 to Day 7.

Equation 1 was used to correlate a population's size in an exponential growth curve:

$$N_T = N_0 e^{rt} \qquad (1)^{15}$$

The population at a given time (N_T) is equivalent to the original population (N_0) multiplied by the value *e* to the power of the product of the growth rate (r) and the time elapsed (t).[16] In order to isolate and discern the r growth rate value, the natural log of Equation 1 was taken to produce an equation for a linear trend line, Equation 2:

$$\ln(N_T) = rt + \ln(N_0) \qquad (2)$$

The value $\ln(N_T)$ was then depicted along a y axis. $\ln(N_0)$ was the intersection of this trend line with the y axis. Value r is the slope of the line and the growth rate of the population. This form of graph was used to determine the growth rate for the populations of *P. micronucleatrum* studied in this experiment. [17]

[14] Enough detail to duplicate but not extraneous (e.g. the test tubes were placed in the holder when not in use) Most entry level lab reports however should lean more towards the over-descriptive side to show the TA / prof that the student followed the directions properly.

[15] Although less common, equations should be presented in this format the first time they are mentioned and referred to subsequently by 'Equation #'.

[16] Important to explain any variables in used equations

[17] Description of graphic analysis used. If statistical analysis also employed in the processing of data, include description here as well.

Results: [18]

The estimated carrying capacity for the 2 populations was determined by placing a horizontal line on the arithmetic graphs of population size change over time. The population beginning with 400 individuals was estimated to have a carrying capacity (K) of 1100 (Figure 1) [19]. It is difficult to estimate this value with extreme confidence because the population growth did not begin leveling off as expected with a logarithmic grow curve population, thus the carrying capacity asymptote line was placed based on the assumption that the highest population recorded (Day 7) was very near the peak of growth. The curve of growth is not the expected; there is a small increase interrupted by a decrease before the population more steadily increases. The population of 800 *P. micronucleatrum* similarly fluctuated, but had an estimate carrying capacity (K) of 1300 (Figure 2). The logarithmic graphs of the populations' growth had similarly shaped curves. The trend line slope for the 400 population's growth was 0.1438, which corresponds to the growth rate value r (Figure 3). The slope of the trend line for population 800 was smaller, at 0.0639 (Figure 4). It is easier to analyze the values of N_0, K and r when organized for comparison (Table 1).

Discussion:[20]

By comparing the 400 and 800 populations, the denser population of *P. micronucleatrum* experienced a greater degree of intraspecific competition. Its carrying capacity higher, but its growth rate was significantly lower than that of the 400 population (Table 1). This supports our hypothesis because the 800 population has less food available per individual, prompting more intense intraspecific competition than that of the 400 population. [21]

There is however when comparing the values of carrying capacities, the results do not support the hypothesis.[22] With less food available, there should be a lower carrying capacity for the 800 population than the 400 population. Instead, the results show that the denser population can

[18] Presentation of processed data (and raw data in entry level courses) in present tense. No analysis, discussion, interpretations, or discussion yet.

[19] This format for Results has all referred tables and figures amassed at the end instead of incorporated into the text. Either is acceptable and usually assigned by the TA / prof. Either way, Figures and Tables referred to using parenthetical citations.

[20] Interpretations and meaning of results outlined in this section. Tie conclusions back to the broader context outlined in the Introduction.

[21] A hypothesis cannot be proven or disproved – only supported or not supported. Must address whether or not the hypothesis was supported in this section.

[22] Different sections of the experiment can support or not support the hypothesis. If so, describe how/why this could be. Don't just pick one.

support 200 more individuals. This is most likely due to human error, both in the estimated counts and in the proper micro-pipetting of observation sample amounts.[23] Several of the observation days included the inaccurate measuring of the observed sample.

This could also be responsible for the unexpected shape of the logistic growth curves. A population with limited resources should have an s-shaped curve, which resembles an exponential line at first and then plateaus when approaching carrying capacity. Another theory is that this patter is the result of a more complicated process of logistic grow; lags between food supply, competition, and population size can cause a populations growth to fluctuate beyond the predicted S curve (Schoener, 1973).[24] This could have influenced the results, even with such a controlled environment and short timescale of study.

In conclusion, the derived growth rates support the hypothesis that the more concentrated population undergoes harsher intraspecific competition; however the carrying capacity values "K" do not support the hypothesis. Clearer and more credible results can be produced by replicating this experiment on a longer time scale in order to allow the population to plateau fully and thus prove where exactly the carrying capacity is for that population. Clearer results will also be produced if this experiment is replicated without any discrepancies in day-to-day sampling methods. Since not every sampling was conducted in the same way because of micro-pipetting inaccuracies, the data trends are not completely definitive. [25]

The implications for studies of competition and intraspecific relations are applicable to nearly all other forms of life. Evolution is a constant process that forces individuals and species to strive for surviving the longest and producing the most offspring . . . Findings, although found in a highly controlled experiment, can be applied to other types of organisms and reveal more about the complexity of the ecological processes in play. [26]

Another implication for this experiment is to expand the densities studied to those with lower and higher densities . . . At extremely low or high densities competition degrees could become unable to stabilize the growth, causing a crash or allowing exponential growth. [27]

Figures and Tables:

[23] Remember to take human error into account – especially for college level reports.
[24] Can connect results to other sources to explain reasoning behind conclusions or connection back to context.
[25] Identify weaknesses of study and improvements to be made in future experiments.
[26] Implications and importance to the broader context described in the introduction
[27] Variations on experiment to try next to offer further insight

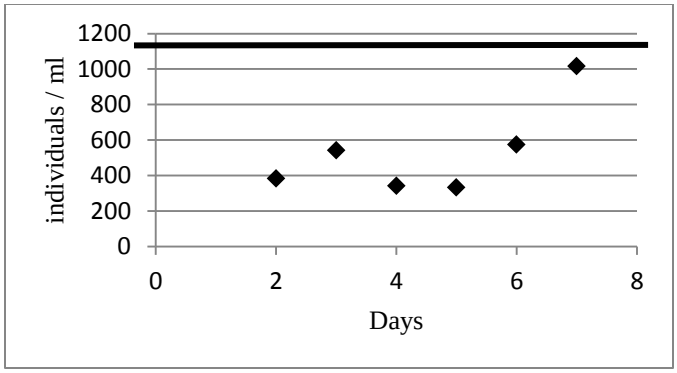
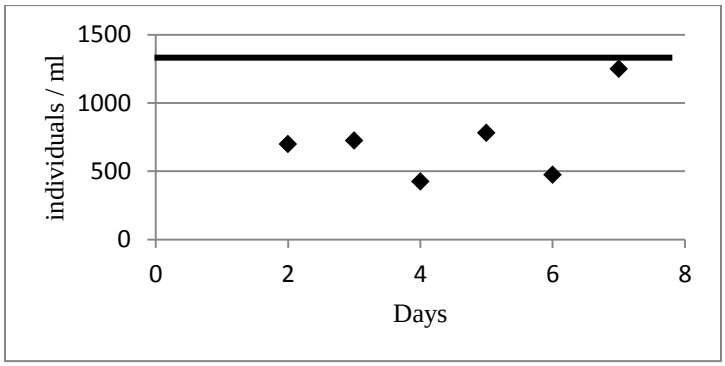


Figure 1 [28]Arithmetic representation of population size of *P. micronucleatrum* population whose N_0 was 400 over 7 days.[29]



[30]

Figure 2 Arithmetic representation of population size of *P. micronucleatrum* population whose N_0 was 800 over 7 days.

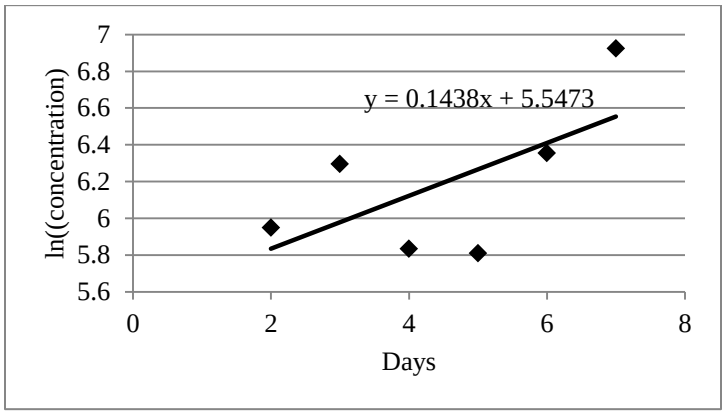


Figure 3 Logarithmic representation of population growth rate of *P. micronucleatrum* population whose N_0 was 400 over 7 days.

[28] Standard to have format be "Figure(space)Number(2 spaces)description" – no bold, italicized, colon, etc Figures first, then tables. Each numbered on their own (Figure 1, Figure 2, Figure 3, Table 1, Table2, etc)

[29] Titles of figures go underneath the figure.

[30] Graphs preferred black and white, clear and simple as possible. DO not need titles since they have descriptions. Axes need labels with units.

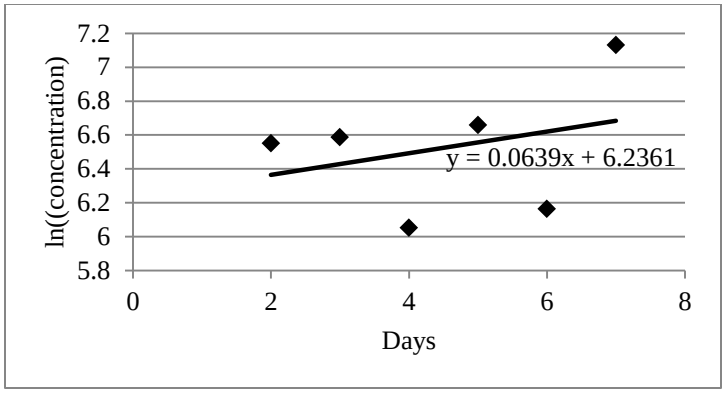


Figure 4 Logarithmic representation of population growth rate of *P. micronucleatrum* population whose N_0 was 800 over 7 days.

Table 1 Carrying capacity and growth rate estimates for *P. micronucleatrum* populations undergoing intraspecific competition.[31]

N_0	Carrying capacity (K)	Growth rate (r)
400	1100	0.1438
800	1300	0.0639

[32]

References:[33]

Schoener, T. W. (1973, March). Population growth regulated by intraspecific competition for energy or time: Some simple representations. *Theoretical Population Biology*, *4*(1). Retrieved April 9, 2014

[31] Title of tables go on top (title put on the table). Same formatting as with figure titles.

[32] Tables do not have vertical lines or perimeter border. Each parameter needs units

[33] Peer reviewed references in APA format, listed in alphabetical order. Typical report usually requires 2-5 sources used in introduction and possibly discussion sections.

BCOR12
Paramecium Ecology Lab Report Rubric

General Writing Style (3):

Writing original (no plagiarism of manual or other outside sources) (1)

Writing style- passive voice or active voice permitted; for active voice, the use of "I" is not accepted. Use "we" since you all did your experiments and analyses in groups. (1)

Formal report – avoid informal terms (eg. don't, doesn't, isn't, slangs) (1)

Title & Abstract (7):

Informative title (1)

Concise writing (1)

Complete content (background, question, methods, results, conclusions) (5)

Introduction (9):

Writing style:

- General to specific organizational structure (3 paragraphs minimum) (3)
- Clear and logical flow of writing (1)

Content:

- Concepts and terms explained correctly (1)
- Question appropriate and clearly presented (1)
- Hypothesis (or hypotheses) clearly stated (1)
- Scientific rationale for hypothesis explained (1)
- Predictions for experiment distinct from hypothesis (1)

Methods (9):

Study organism(s) described (1)

All components of experiment described (2)

Relevant formulas and calculations described (1)

Sufficient details provided to repeat experiment (2)

Rationale provided for each component of experiment (2)

Routine process tasks are omitted (1)

Results (8):

Writing style:

- Written in past tense (passive or active voice permitted) (1)
- No methods or discussion content in results section (1)

Text and figures stand alone (1)

- Figures and tables numbered and referenced in text appropriately (1)

Content:

- Results are fully described (2)
- Figures are of correct type and contain appropriate data to illustrate results (1)
- Figure and table captions describe content (1)

Discussion (10):

Writing style:

- Writing clear and logical (1)
- Paragraphs organized with topic sentences (1)

Content:

- Demonstrates how data do or do not support the hypothesis (1)
- Discusses all major aspects of the results (2)
- Discusses alternative hypotheses/sources of error (1)
- Discusses two implications of the results (one paragraph for each) (2)

External sources:

- At least one supporting citation included (1)
- Citation content integrated into argument (1)

References Cited (3):

Citation from peer-reviewed journal (1)

Correct citation formatting in text (1)

Citation information presented in standard format (1)

Participation (1):

Individual participation in out-of-class counting (1pt)