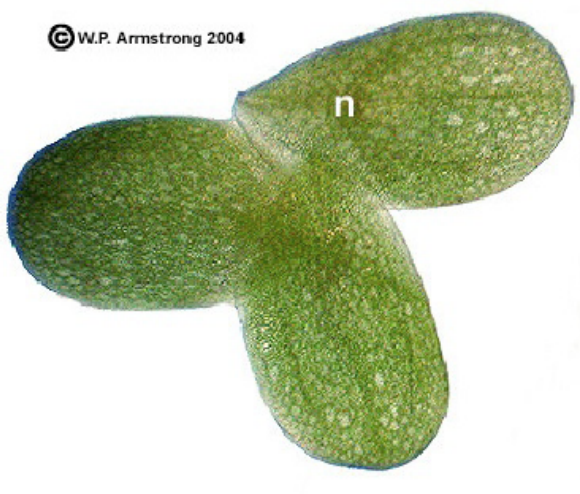
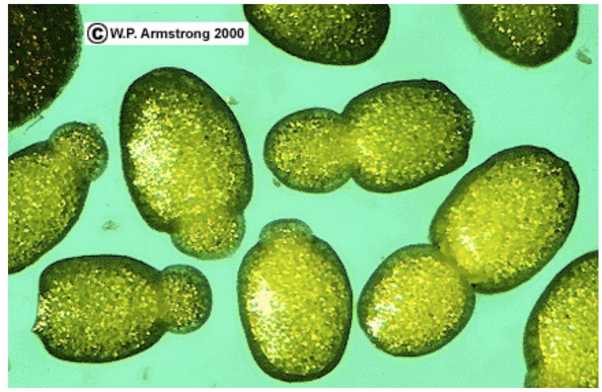
Biology 229
Prof. Kerkhoff

Ecology Laboratory
2-5-2010

Population Growth and Competition II





Lemna *Wolffia*

REVIEW EXPERIMENTAL DESIGN

First, recall your initial observations, hypotheses, and experimental design.

What did we manipulate, and at what levels?
What are the replicates?
What were your hypotheses concerning population growth in response to resource limitation?
What were your hypotheses concerning competitive outcomes between *Lemna and Wolffia* competing at different resource levels?

DATA ANALYSIS NOTES

Preliminary observations – look at the data

For EACH TREATMENT, examine how the mean number of plants changed over time. Do any general patterns emerge?

SINGLE SPECIES POPULATION GROWTH

Growing from small numbers, we would expect the populations to initially show exponential growth:

$$N_t = N_0e^{rt}.$$

If we take the logarithm of both sides of this equation, we get

$$\log N_t = \log N_0 + rt$$

So now if we plot logN as a function of t, the slope of a line fit to the data gives us an estimate of r, the per capita rate of increase.

Departures from a linear relationship, especially a rounding-over towards the end of the experiment, indicate that population growth rate is not purely exponential – the species may be coming up against some sort of resource limitation. They may be approaching carrying capacity, K, so a logistic model of the following form may be more appropriate:

$$dN/dt = r_{max}N(1 - N/K)$$

One way to assess this is to look at how the instantaneous growth rate changes as the population gets larger. Looking from timestep to timestep, we can look at population growth this way:

$$N_{t+1} = e^r N_t = \lambda N_t$$

Here, λ provides is the *realized* population growth rate, which we can calculate for each timestep just by using algebra:

$$N_{t+1}/N_t = \lambda$$

Under the logistic growth model, the realized population growth rate should decline linearly with increasing population size, reaching zero when the population is at carrying capacity. So, if we graph λ as a function of population size, we can estimate K by observing, or extrapolating where the data would cross the X-axis.

Single Species Population Growth Questions

- In this experiment, would population growth be better described by an exponential or a logistic model? Does the appropriate model change depending on the resource conditions? How well does the model fit the patterns of the data?
- Does the growth rate and/or the carrying capacity of each species respond to the resource level? Do they respond in the same way?
- Which species appears to have a higher maximum population growth rate? Which appears to have a higher carrying capacity?

INTERSPECIFIC COMPETITION

Competition Theory

One way to model competition between two species (call them i and j), is to extend the logistic model into a system of two equations

$$dN_i/dt = r_iN_i(1 - N_i/K_i - \alpha_{ij}N_j/K_i)$$

$$dN_j/dt = r_jN_j(1 - N_j/K_j - \alpha_{ji}N_i/K_j)$$

The additional term in each equation (e.g., $\alpha_{ij}N_j/K_i$) can be roughly interpreted as the number of individuals of species j that it would take to equal a single individual of species i in terms of their effect on the realized rate of increase of species i.

Measuring interspecific competition is never simple. One way to do it is to consider how the presence of a second species impacts the growth rate of the other. On the other hand, we can also consider how the presence of the other species impacts the carrying capacity of the focal species.

In the first case, we can compare the realized growth rate (λ above) for the species grown when grown together to that found when grown in monoculture. The difference provides an estimate of the impact of the competitor. This gives us an estimate of the competitive impact of one species on the growth rate of the other (i.e., $\alpha_{ij}N_j/K_i$ above).

Likewise, we can compare the estimates of carrying capacity for the species grown in isolation with those found when the species were grown together.

Interspecific Resource Competition Questions

- Do we observe negative effects of interspecific competition?
- Is the outcome and/or the strength of competition affected by the resource environment? Do low or high resource levels appear to favor one species over the other?
- Put another way, is there an *interaction* between the resource environment and the competitive environment in their effects on population growth?

ASSIGNMENT: DUE AFTER BREAK

Prepare an analysis of our resource competition experiment in the form of a scientific paper, with the usual abstract, introduction, methods, results, discussion and literature cited sections. Use whatever appropriate graphical and statistical results you deem necessary to address the underlying hypotheses we developed as a class. The paper by Lemon, posted on the website, is a good starting place for gathering some background in the published literature, and I will expect at least one other relevant primary citation.

<u>Supplemental reference:</u>

Lemon, G. D., U. Posluszny, and B. C. Husband. 2001. Potential and realized rates of vegetative reproduction in *Spirodela polyrhiza*, *Lemna minor*, and *Wolffia borealis*. Aquatic Botany 70:79-87.