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Depression in Thermal Performance of Age-Structured *Spirodela polyrhiza* due to the Presence of *Rhopalosiphum nymphaeae*

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Introduction

Plant population dynamics are influenced by temperature and herbivory. Temperature dependence on growth can be modeled using thermal performance curves, and the effects of herbivory have been modeled with consumption rates and herbivore/plant physiological performance.[1] While these approaches have been tested across a range of temperatures, such studies have focused on temperature-dependent feeding rates.[2] Little research has been done on the combined effects of temperature and herbivory on plant population growth and reproduction, and none (to our knowledge) have related the thermal performance of herbivore population growth to thermal performance of the plant population. We use age-structured models including the temperature-dependent effects of herbivory on plant reproduction and growth, allowing us to test for different effects between adult and juvenile portions of the population.

Goals & Objectives

The aim of this study was to find a suitable thermal performance curve to fit age-structured *Spirodela polyrhiza* growth. This curve was used to model depression in population growth caused by the presence of the herbivore *Rhopalosiphum nymphaeae.*

Methods

- 127 duckweed colonies were grown without aphids at temperatures from 9.25 to 38.6°C. 59 duckweed-aphid communities were grown at temperatures from 15.9 to 29.35°C.
- AIC and maximum likelihood were used to fit and compare the duckweed-only and duckweed-aphid models.
- Regression analysis gave the relationship between aphid thermal performance and depression in duckweed thermal performance.

Results

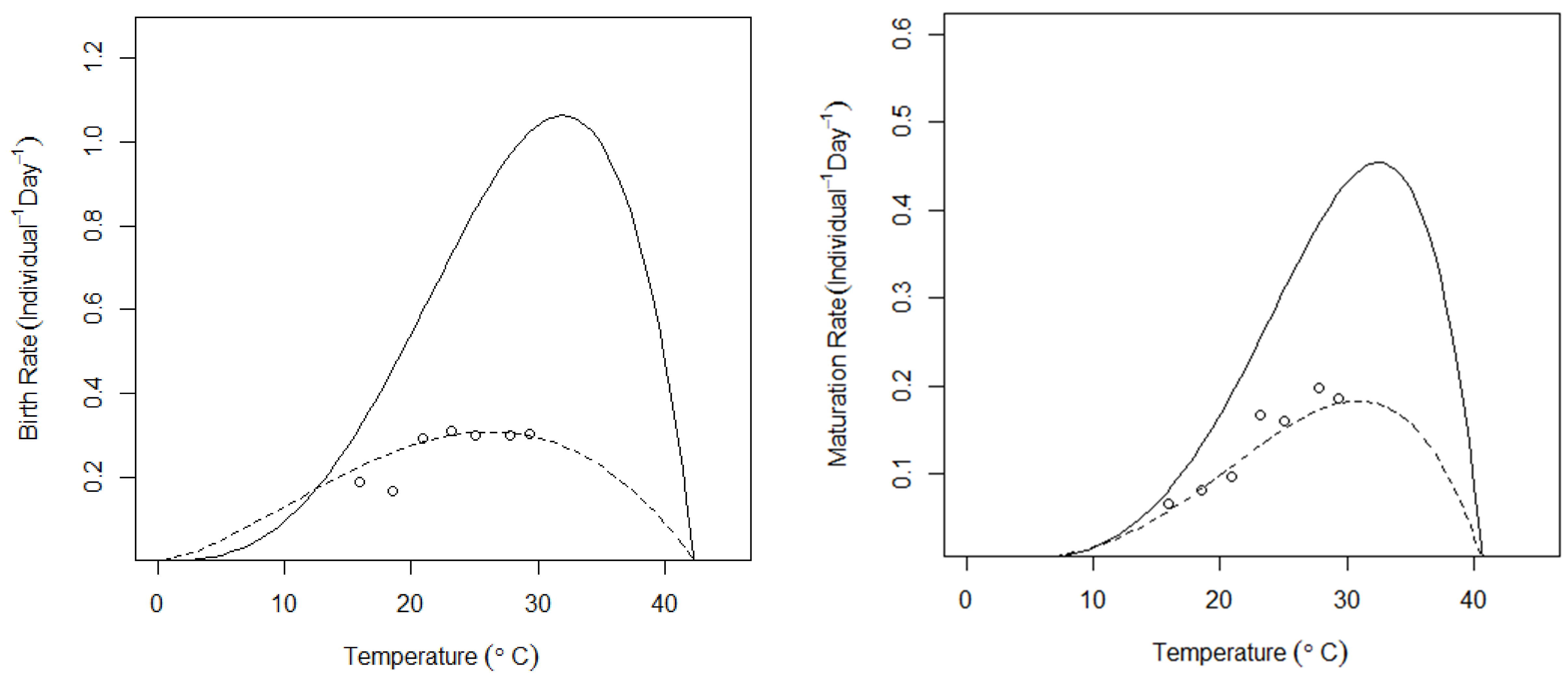

Fig 1: *Yan-Hunt* equations fit to the duckweed-only (solid line) and duckweed-aphid (dashed line) experimental data. Data points are log-likelihood averages of birth (left) and maturation (right) rates in the presence of aphids at experimental temperatures.

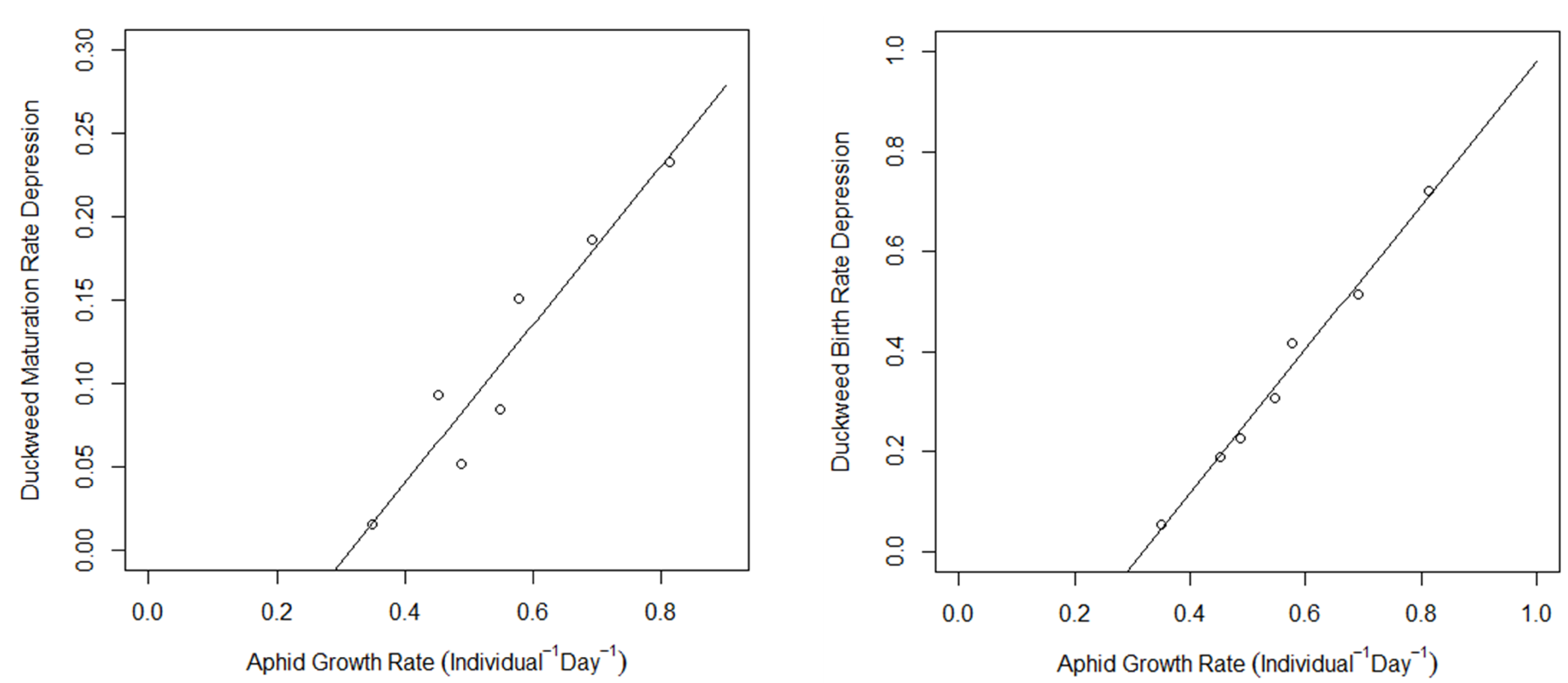

Fig 2: (Left) Reduction in duckweed maturation rate increased with aphid growth (m=0.477, R2=0.894, p<0.001). ***(Right)*** Reduction in duckweed birth rate increased with aphid growth (m=1.4378, R^2=0.985, p<0.001)

[1] Schulte PM, Healy TM, Fangue NA. Thermal Performance Curves, Phenotypic Plasticity, and the Time Scales of Temperature Exposure. Integr. Comp. Biol. 2011.
[2] Barbeau MA, Scheibling RE. Temperature effects on predation of juvenile sea scallops by sea stars and crabs. Jour. of Exp. Biol. and Eco. 1994: 182:27-47.

Results (cont.)

The *Yan-Hunt* equation given by:

$$\mu(T) = \mu_{max}\left(\frac{T_{max}-T}{T_{max}-T_{opt}}\right)\left(\frac{T}{T_{opt}}\right)^{\frac{T_{opt}}{T_{max}-T_{opt}}}$$

was the best fit model for duckweed maturation (AIC=1562) and had the least number of parameters, all of which are applicable to the experimental data.

AIC analysis of duckweed-only (above) and duckweed-aphid models showed significant differences in maximum temperature, optimal temperature, as well as μ_max for both maturation and birth rates.

Regression showed that depression in duckweed birth and maturation was due to aphid presence and was directly proportional to thermal performance of aphid populations.

Discussion

We concluded that duckweed maturation and birth rates can both be best described using the Yan-Hunt thermal performance curve, which accurately captures trends that occur around optimal temperature. Furthermore, aphids have a significant, temperature-dependent impact on the performance of duckweed, decreasing maximum birth and maturation rates as well as lowering optimal and maximal temperatures at which duckweed survive. This depression in maturation and birth rates across temperatures was directly proportional to the thermal performance of aphid growth rates. This relationship shows the importance of including temperature when modeling producer-consumer dynamics; as these dynamics have been shown to rely heavily on relative growth across temperatures without the need for consumption rates or physiological data. This leads to the idea of modeling herbivore-plant population dynamics using nested thermal performance models.