

Model Document: Research Proposal

Field Measurements of
Photosynthesis and Transpiration
Rates in Dwarf Snapdragon
(*Chaenorrhinum minus* Lange):
An Investigation of Water Stress
Adaptations

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Introduction

Dwarf snapdragon (*Chaenorrhinum minus*) is a weedy pioneer plant found growing in central New York during spring and summer. Interestingly, the distribution of this species has been limited almost exclusively to the cinder ballast of railroad tracks ¹ and to sterile strips of land along highways ². In these harsh environments, characterized by intense sunlight and poor soil water retention, one would expect *C. minus* to exhibit anatomical features similar to those of xeromorphic plants (species adapted to arid habitats).

However, this is not the case. T. Gupta and R. Arnold (unpublished) have found that the leaves and stems of *C. minus* are not covered by a thick, waxy cuticle but rather with a thin cuticle that is less effective in inhibiting water loss through diffusion. The root system is not long and thick, capable of reaching deeper, moister soils; instead, it is thin and diffuse, permeating only the topmost (and driest) soil horizon. Moreover, in contrast to many xeromorphic plants, the stomata (pores regulating gas exchange) are not found in sunken crypts or cavities in the epidermis that retard water loss from transpiration.

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Despite a lack of these morphological adaptations to water stress, *C. minus* continues to grow and reproduce when morning dew has been its only source of water for up to 5 weeks (2002 letter from R. Arnold to me). Such growth involves fixation of carbon by photosynthesis and requires that the stomata be open to admit sufficient carbon dioxide. Given the dry, sunny environment, the time required for adequate carbon fixation must also mean a significant loss of water through transpiration as open stomata exchange carbon dioxide with water. How does *C. minus* balance the need for carbon with the need to conserve water?

Purposes of the Proposed Study

The above observations have led me to an exploration of the extent to which *C. minus* is able to photosynthesize under conditions of low water availability. It is my hypothesis that *C. minus* adapts to these conditions by photosynthesizing in the early morning and late afternoon, when leaf and air temperatures are lower and transpirational water loss is reduced. During the middle of the day, its photosynthetic rate may be very low, perhaps even zero, on hot, sunny afternoons. Similar diurnal changes in photosynthetic rate in response to

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midday water deficits have been described in crop plants^{3,4}. There appear to be no comparable studies on non-crop species in their natural habitats.

Thus, the research proposed here aims to help explain the apparent paradox of an organism that thrives in water-stressed conditions despite a lack of morphological adaptations. This summer's work will also serve as a basis for controlled experiments in a plant growth chamber on the individual effects of temperature, light intensity, soil water availability, and other environmental factors on photosynthesis and transpiration rates. These experiments are planned for the coming fall semester.

Methods and Timeline

Simultaneous measurements of photosynthesis and transpiration rates will indicate the balance *C. minus* has achieved in acquiring the energy it needs while retaining the water available to it. These measurements will be taken daily from June 22 to September 7, 2003, at field sites in the Hamilton, NY, area, using an LI-6220 portable photosynthesis system (LICOR, Inc., Lincoln, NE). Basic methodology and use of correction factors will be similar to that described in related studies⁵⁻⁷. Data will be collected at regular intervals throughout the

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daylight hours and will be related to measurements of ambient air temperature, leaf temperature, relative humidity, light intensity, wind velocity, and cloud cover.

Budget

1 kg soda lime, 4-8 mesh (for absorption of CO ₂ in photosynthesis analyzer)	\$70
1 kg anhydrous magnesium perchlorate (used as desiccant for photosynthesis analyzer)	\$130
SigmaScan software (Jandel Scientific Software, Inc.) (for measurement of leaf areas for which photosynthesis and transpiration rates are to be determined)	\$195
Estimated 500 miles travel to field sites in own car @ \$0.28/mile	\$140
CO ₂ cylinder, 80 days rental @ \$0.25/day (for calibration of photosynthesis analyzer)	\$20
TOTAL REQUEST	\$555

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References

1. Wildrlechner MP. Historical and phenological observations of the spread of *Chaenorrhinum minus* across North America. *Can J Bot.* 1983;61(1):179–187.
2. Dwarf Snapdragon [Internet]. Olympia (WA): Washington State Noxious Weed Control Board; 2001 [updated 2001 Jul 7; cited 2003 Jan 25]. Available from: http://www.wa.gov/agr/weedboard/weed_info/dwarfsnapdragon.html
3. Boyer JS. Plant productivity and environment. *Science.* 1982 Nov 6:443–448.
4. Manhas JG, Sukumaran NP. Diurnal changes in net photosynthetic rate in potato in two environments. *Potato Res.* 1988;31:375–378.
5. Doley DG, Unwin GL, Yates DJ. Spatial and temporal distribution of photosynthesis and transpiration by single leaves in a rainforest tree, *Argyrodendron peralatum*. *Aust J Plant Physiol.* 1988;15(3):317–326.
6. Kallarackal J, Milburn JA, Baker DA. Water relations of the banana. III. Effects of controlled water stress on water potential, transpiration, photosynthesis and leaf growth. *Aust J Plant Physiol.* 1990;17(1):79–90.

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7. Idso SB, Allen SG, Kimball BA, Choudhury BJ. Problems with porometry: measuring net photosynthesis by leaf chamber techniques. *Agron.* 1989;81(4):475–479.