*Clarkia unguiculata*

# Understanding the Relationship Between Physiology and Fruit Set *Clarkia unguiculata* and *Clarkia exilis*

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*Clarkia exilis*

## Abstract

Plants are under constant risk of desiccation, how plants deal with this risk may be influenced by or influence their mating system. Because of this, we are exploring whether selfing plants differ from outcrossing plants in regards to how they cope with their habitats. In *Clarkia,* endemic to the western United States, previous work has shown different physiological rates between selfing (self-pollinating) species *Clarkia exilis* and the outcrossing (have pollinators) close relative *Clarkia unguiculata* such as a higher photosynthetic rate in the selfers. Additionally, selfers go through their life cycle at an accelerated rate compared to their outcrossing sister taxa, which flower later on in the season. Consequently, outcrossing plants experience lower water availability that could negatively effect reproductive fitness. We examine how efficient *C. exilis* and *C. unguiculata* are at using water (Water-use efficiency, WUE) and relate this to components of fitness, total fruit production and fruit set. For total fruit production, *C. exilis* and *C. unguiculata* varied with developmental stage (preflowering or flowering). Our study demonstrates a consistently weak relationship between WUE and fruit set in *C. exilis*; whereas, we found a negative correlation between WUE and fruit set in the outcrossing species *C. unguiculata.* Our data shows some support for our prediction that the outcrosser will have a stronger dependency on gas-exchange rates. However, the negative relationships are contrary to our predictions and we are now considering microhabitats as a possible factor explaining these findings.

## Introduction

- Many selfing taxa tend to grow in hotter and drier environments than their outcrossing sister taxa
- In *Clarkia*, selfing taxa also tend to flower earlier than their outcrossing counterparts when in sympatry
- Here, we use the selfer *C. exilis* and its outcrossing progenitor *C. unguiculata* to test:
- If fitness of outcrossers is related to increased physiological rates
- Specifically, is
  1) total fruit production positively related to water use efficiency, and is
  2) fruit set positively related to water use efficiency
  3) is the relationship stronger in the outcrosser compared to the selfer (i.e. is the slope steeper)


Population distributions of *C. exilis* and *C. unguiculata*


Study sites containing *C. unguiculata* and *C. exilis*

View of Lake Isabella

*C. unguiculata*

*C. exilis*


A mature fruit (left) and aborted fruit (right)

## Methods

- 4 sites contained *C. unguiculata* and 2 contained *C. exilis*
- Took physiological data using an infrared gas exchange analyzer
- Collected 60 Pre-flowering and 60 Flowering plants per population
- Quantified fruit set (#fruits/#flowers): counted mature well formed fruits and aborted fruits. Counted empty nodes
- Measured leaf area to standardize physiological data

● - Individual *C. exilis* plant

● - Individual *C. unguiculata* plant

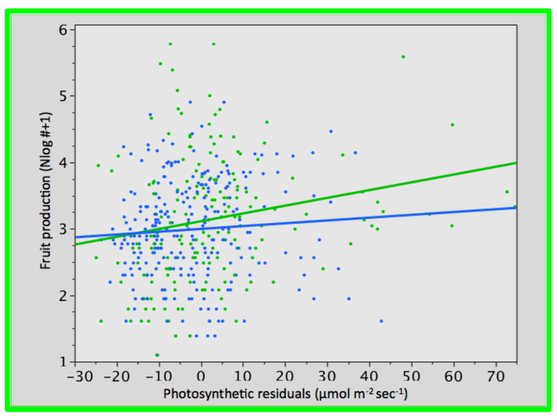


Figure 1. Best fit lines between photosynthetic residuals and fruit production ( *C. exilis* fruit number = 0.01 (Photosynthetic residuals) +3.1, $R^2$= 0.04; *C. unguiculata* fruit number = 0.004 (Photosynthetic residuals) +3.0, $R^2$= 0.005)

- Positive relationship between photosynthetic residuals and fruit production in *C. unguiculata*.
- Weak relationship between fruit production and photosynthetic residuals in *C. exilis*

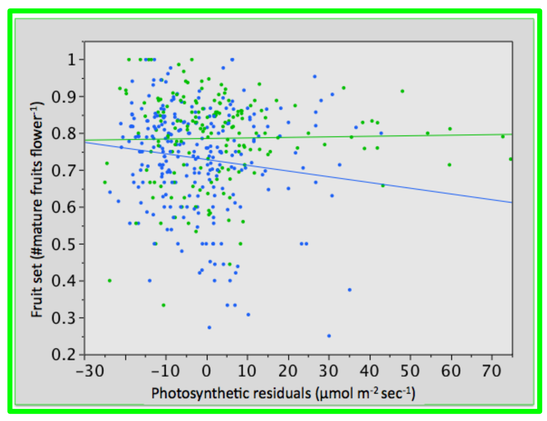


Figure 4. Best fit lines between photosynthetic residuals and fruit set (C. exilis fruit set = 0.0002 (Photosynthetic residuals) +0.79, $R^2$ = 0.0004; C. unguiculata fruit set = -0.002 (Photosynthetic residuals) +0.73, $R^2$= 0.02)

- Negative relationship between photosynthetic residuals and fruit set in *C. unguiculata*.
- Weak relationship between photosynthetic residuals and fruit set in *C. exilis*

■ - *C. exilis*

■ - *C. unguiculata*

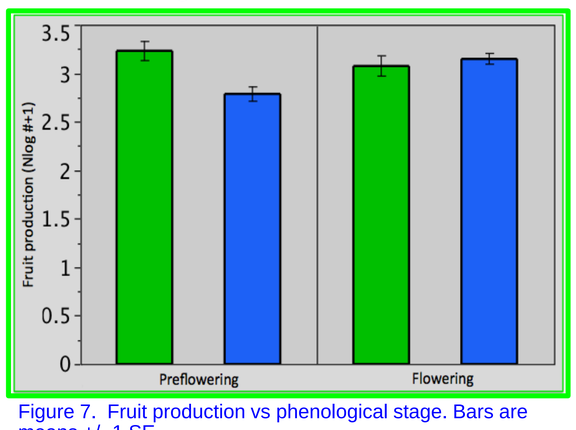


Figure 7. Fruit production vs phenological stage. Bars are means +/- 1 SE

- *C. exilis* Pre-flower had highest fruit production. *C. unguiculata* had lowest fruit production

Pre-flowering Flowering

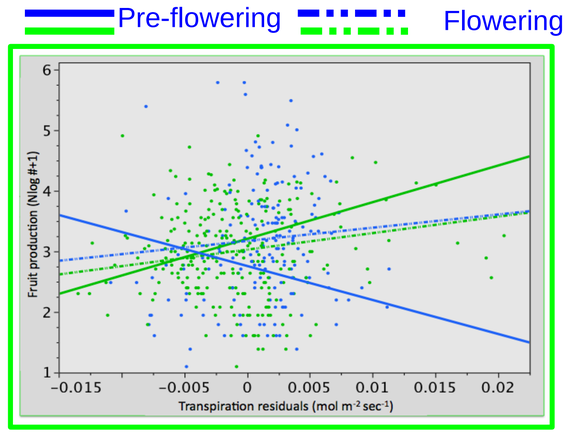


Figure 2.Best fit lines between transpiration residuals and fruit production (Flowering *C. exilis* fruit number = 27.3 (Transpiration residuals) +3.0,$R^2$= 0.01; Pre-flowering *C. exilis* fruit number = 60.53 (Transpiration residuals +3.0, $R^2$= 0.05; Flowering *C. unguiculata* fruit number =21.8 (Transpiration residuals) +3.2, $R^2$= 0.05; Pre-flowering *C. unguiculata* fruit number = -56.1 (Transpiration residuals) + 2.8, $R^2$= 0.04)

- Positive relationships between transpiration residuals and fruit production in Flowering and Pre-flowering *C. exilis*.
- Negative relationship between transpiration residuals and fruit production in Flowering *C. unguiculata*.
- Positive relationship between transpiration residuals and fruit production in Pre-flowering *C. unguiculata.*

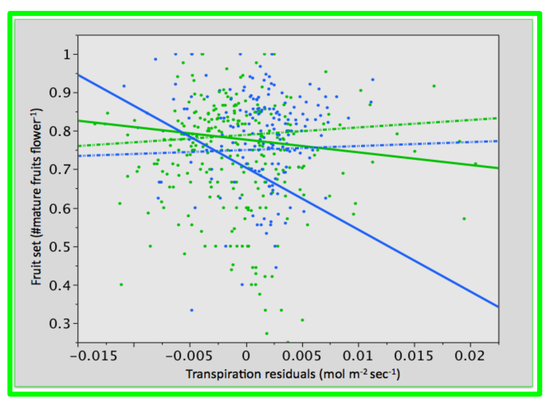


Figure 5. Best fit lines between transpiration residuals and fruit set (Flowering *C. exilis* fruit set = 1.07(Transpiration residuals) + 0.79, $R^2$=0.002; Pre-flowering *C. exilis* fruit set = -3.3(Transpiration residuals) +0.78,$R^2$= 0.008; Flowering *C. unguiculata* fruit set = 1.03(Transpiration residuals) +0.75, $R^2$=0.003; Pre-flowering *C. unguiculata* fruit set = -16.8 (Transpiration residuals) + 0.70, $R^2$= 0.08)

- Negative relationship between transpiration residuals and fruit set in Flowering *C. exilis* and *C. unguiculata.*
- Weak relationships between transpiration residuals and fruit set in Pre-flowering *C. exilis* and *C. unguiculata*.

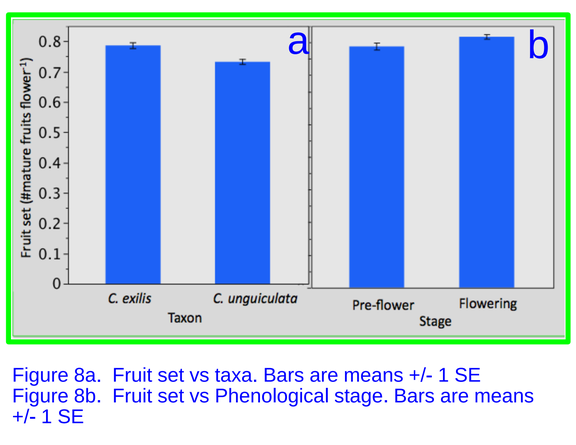


Figure 8a. Fruit set vs taxa. Bars are means +/- 1 SE
Figure 8b. Fruit set vs Phenological stage. Bars are means +/- 1 SE

- *C. exilis* had higher fruit set than *C. unguiculata*.
- Flowering stage had higher fruit set than Pre-flowering stage.

| | Fruit set | | | | Fruit number | | | |
|---|---|---|---|---|---|---|---|---|
| Independent effects | No covariate | Photosynthetic residuals | Transpiration residuals | Water use efficiency residuals | No covariate | Photosynthetic residuals | Transpiration residuals | Water use efficiency residuals |
| Taxon | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 0.0219 | 0.0905 | 0.0717 | 0.0022 |
| Stage | 0.0287 | 0.0237 | 0.0205 | 0.0102 | 0.2074 | 0.0458 | 0.1583 | 0.0163 |
| Covariate | | 0.2246 | 0.0113 | 0.3942 | | <0.0001 | 0.2240 | 0.0017 |
| Taxon x stage | 0.4721 | | 0.2607 | | 0.0014 | 0.0016 | 0.0004 | 0.0819 |
| Taxon x covariate | | 0.0491 | 0.0560 | 0.0504 | | 0.0506 | 0.0057 | 0.0097 |
| Stage x covariate | | | 0.0018 | | | 0.0010 | 0.3095 | 0.0303 |
| Taxon x stage x covariate | | | 0.0575 | | | | 0.0117 | 0.0257 |
| Model | | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |

Table 1. P-values from two Analyses of Variance and several Analyses of Covariance. Empty cells for covariate models indicate effects left out of the final model and error pooled due to P>0.2 in previous models in which they were included.

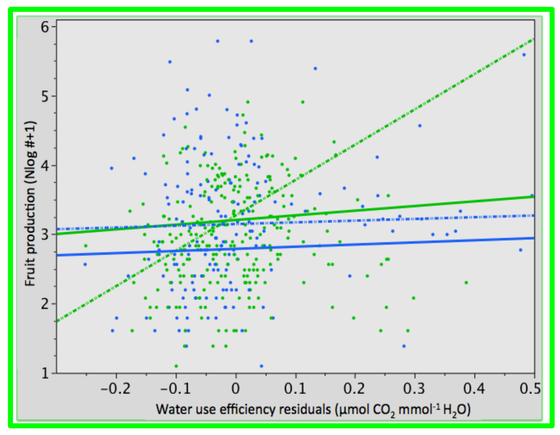


Figure 4. Best fit lines between Water-use efficiency residuals and fruit production (Flowering *C. exilis* fruit number = 5.1 (Water-use efficiency residuals) +3.3, $R^2$=0.07; Pre-flowering *C. exilis* fruit number = 0.67 (Water-use efficiency residual) +3.2, $R^2$= 0.02; Flowering *C. unguiculata* fruit number = 0.25 (Water use efficiency residuals) +3.1,$R^2$=0.001; Pre-flowering *C. unguicuata* fruit number = 0.31 (Water-use efficiency residuals) +2.8,$R^2$= 0.002)

- Weak relationships between water-use efficiency and fruit production in Flowering *C. exilis* and Flowering *C. unguiculata*.
- Weak relationship between water-use efficiency and fruit production in Pre-flowering *C. unguiculata*.
- Positive relationship between water-use efficiency in Pre-flowering *C. exilis*.

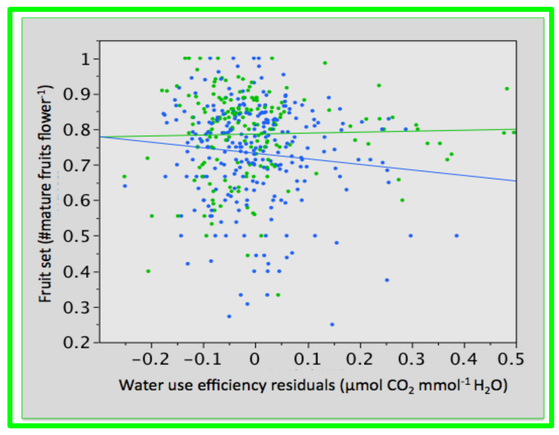


Figure 6. Best fit lines between Water-use efficiency residuals and fruit set (*C. exilis* fruit set = 0.03 ( Water-use efficiency residuals) +0.79, $R^2$= 0.0008; *C. unguiculata* fruit set = -0.16 ( Water-use efficiency residuals) +0.73, $R^2$=0.01)

- Weak relationship between water-use efficiency and fruit set in *C. exilis*.
- Negative relationship between water-use efficiency and fruit set in *C. unguiculata*

## Conclusions

- Water-use efficiency is weakly affecting fruit set.
- Microhabitats may be an explanation for the negative relationship between physiology and fruit set in *C. unguiculata*
- Future work: include microhabitat differences in data exploration.

References

- Dudley, A. Susan. 1996. Differing Selection on Plant Physiological Traits in Response to Environmental Water Availability: A Test of Adaptive Hypothesis. *Evolution* 50,92-102
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