

Effects of high and low light intensity on the exchange of cellular respiration gases in
Vicia faba* and *Blaberus

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Physiological Dynamics of Animals and Plants

Introduction

Arthropods and plants have similar mechanisms for gas exchange. The waxy cuticle in plants and the chitinous exoskeleton in arthropods both serve as protective covering and a form for water retention. Gas exchange occurs across these boundaries via specialized pores in the organism's outer surface. In plants, stomata are small pores found on leaves that can be opened and closed to regulate gaseous levels inside the leaf (Mansfield and Davies 1985). Similar to stomata, spiracles in arthropods open and close for gas exchange (Lighton 1996, 1998).

Ambient conditions such as temperature, humidity, and carbon dioxide concentrations have been found to influence the rate of cellular processes and thus gas exchange (Guthrie and Tindall 1968; Mansfield and Davies 1985). Light quality and quantity influence the degree that stomata open (Mansfield and Davies 1985). Our study examines the effect of light intensity on the exchange of respiratory gases in plants and arthropods, specifically faba beans, *Vicia faba*, and giant cockroaches, *Blaberus* sp..

Hypothesis

If a controlled concentration of oxygen gas and carbon dioxide is run over the surface of a leaf under light and dark conditions (assuming stomata are open and photosynthesis is inhibited) then an increased carbon dioxide concentration (thus a lower oxygen gas percentage) will result

under the light conditions in comparison to the dark. If the same conditions are run on a cockroach then the same result of increased carbon dioxide under light conditions will occur indicating a general trend for increased respiration in light for plants and arthropods.

Methods for measuring plant respiration

In order to insure open stomata in dark conditions we applied a fusicoccin solution (10 μ M fusicoccin and 5mM KCl) to the leaves 24 hours before testing began. Five hours before testing we applied a dilute solution of DCMU (1mL:100mL H₂O) to the leaves to inhibit photosynthesis and assure that the only gas exchange occurring was from cellular respiration.

Results

Plant:

Carbon dioxide concentrations fluctuated slightly under both light and dark conditions but remained within close proximity to the initial concentration of 350 ppm. The average CO₂ concentration in the dark was 358.32 ± 1.46 ppm and 362.51 ± 7.24 ppm in the light. The concentrations of CO₂ over the entire testing period can be seen in Figure 1.

Figure 2 shows the percent of oxygen gas leaving the chamber after being run over the leaf surface. The average percent of O₂ under dark conditions is 20.91 ± 0.02 while the average O₂ percentage in the light is 20.87 ± 0.02 .

Cockroach:

The cockroaches clearly demonstrated discontinuous gas exchange under dark conditions with a sharp rise and fall of CO₂ concentrations. Under light conditions the discontinuous gas exchange was not as clearly defined with only small increases in CO₂ (Figure 3). An increase of

270.99 ppm and 228.05 ppm occurred in the dark while increases of 74.35 ppm and 153.964 were seen in the dark.

The oxygen content remained stable in both conditions showing rises and falls in conjunction with the corresponding CO₂ concentration (Figure 4).

Discussion

Our results indicate that light intensity does not influence respiratory gas exchange in plants. The rise in CO₂ seen near the end of the testing period (Figure 1) is attributed to the air supply running out allowing an uncontrolled amount of gas to pass through the system. The initial rises and falls of the CO₂ concentrations in both the light and dark tests are due to the system clearing out the air that entered into the system when inserting the leaf. All changes in the percent O₂ are directly correlated with the changes in CO₂ concentration.

While discontinuous gas exchange occurred in both light and dark conditions, the cockroaches demonstrated a clearer respiratory cycle in the dark. When in the dark the cockroaches remained relatively inactive while in the light they remained constantly active in attempts to find dark cover. This leads us to believe that when resting cockroaches have a regular respiration pattern but when under stressful conditions irregular respiration occurs. As with the plants, the O₂ percentage changed with CO₂ fluctuation.

Overall, these data suggest that light intensity does not influence the cellular processes associated with respiratory gas exchange in plants or arthropods.

FIGURE 1: Plant Light and Dark Carbon Dioxide Concentrations

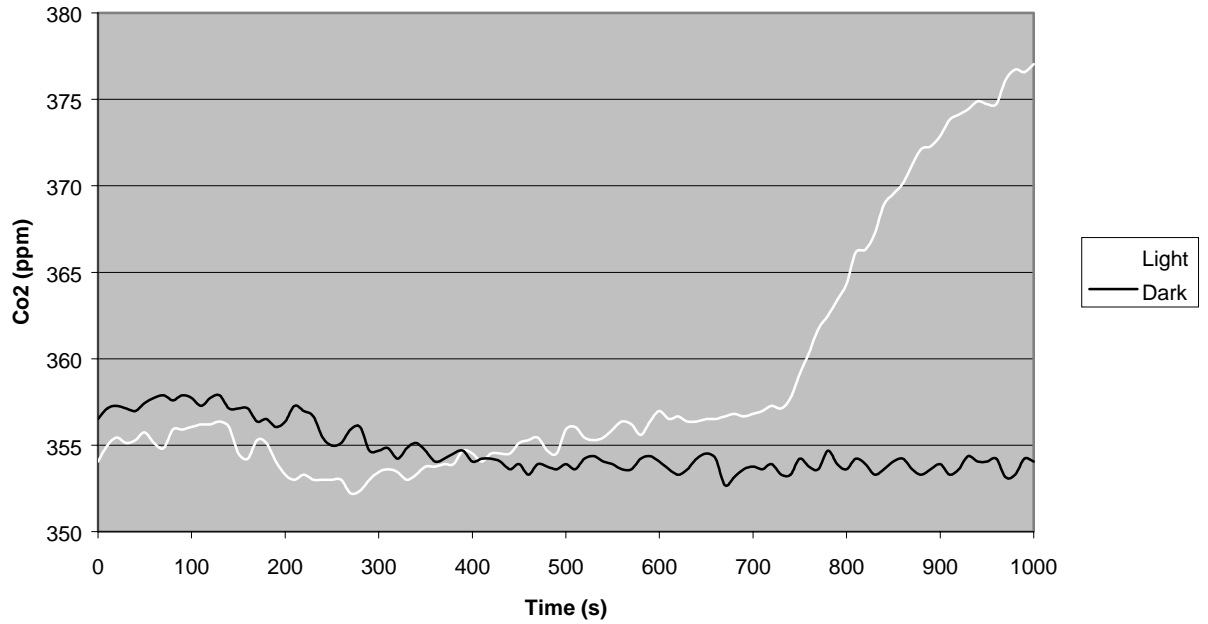


FIGURE 2: Plant Light and Dark Oxygen Percentages

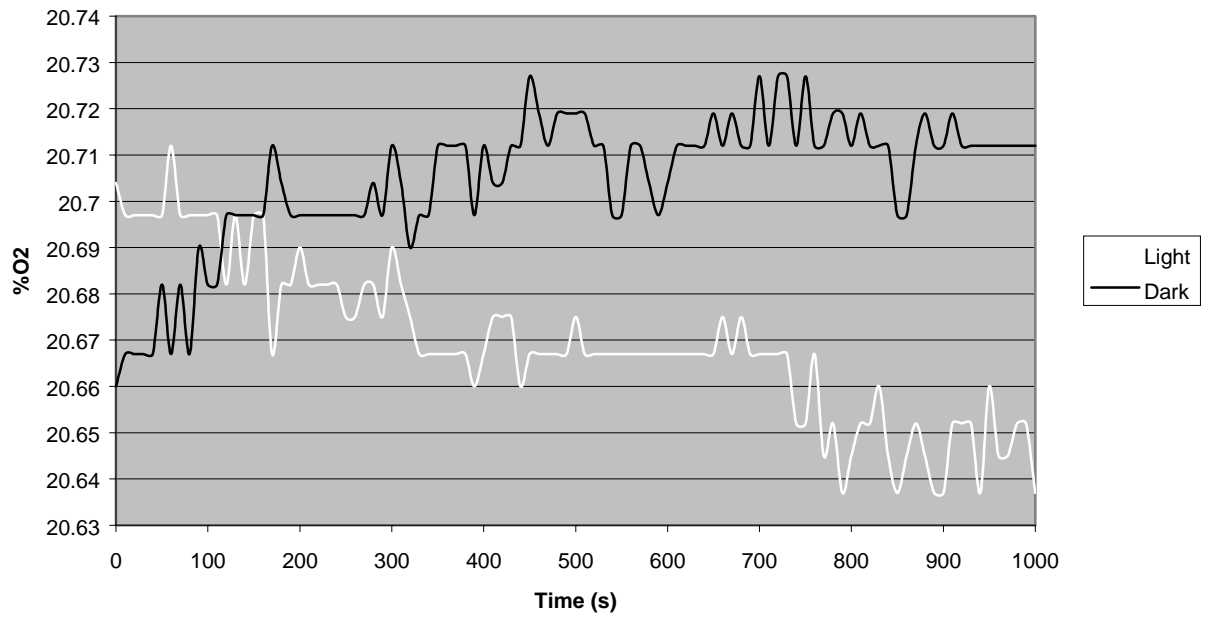


FIGURE 3: Cockroach Light and Dark Carbon Dioxide Concentrations

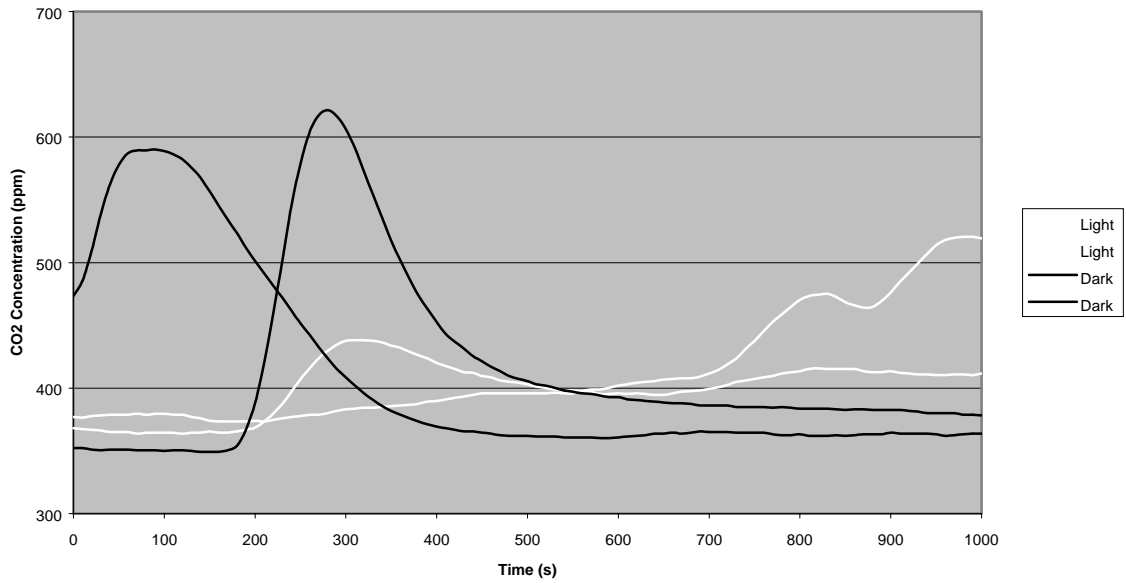
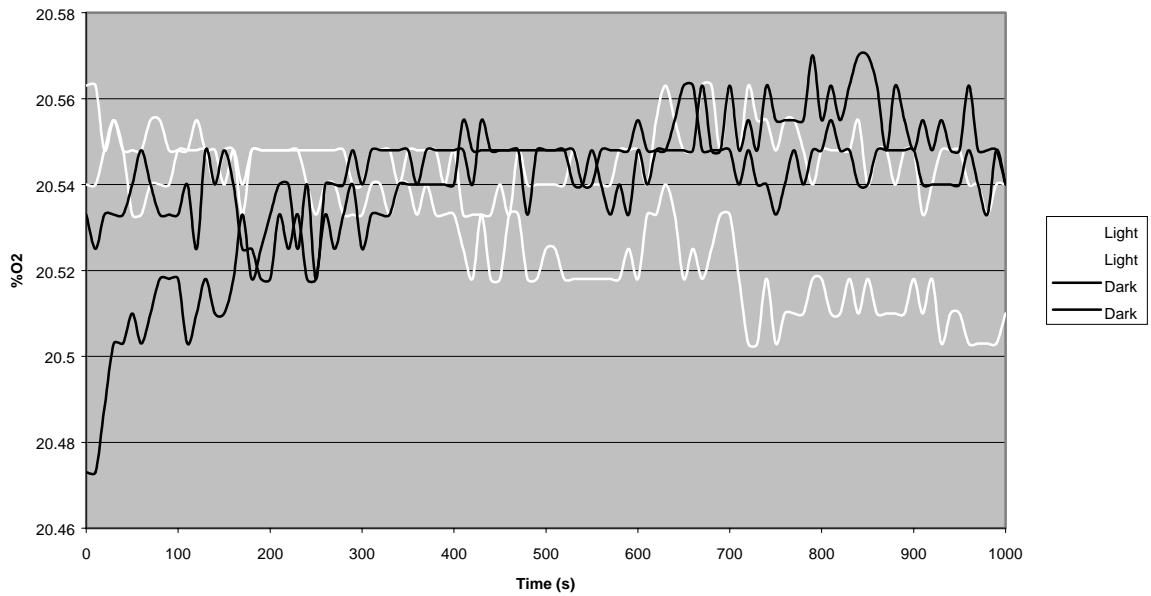


FIGURE 4: Cockroach Light and Dark Oxygen Percentages



References

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