Comparative Study of Gas Exchange in Terrestrial Organisms:

Effect of Silicone Lubricant on Gas Exchange in the *Vicia faba* bean plant and *Blaberus gigantea*, the Giant Cockroach

Jacob Berg
With Fiona Lee & Molli Knudson

Introduction

Cellular respiration in plants and animals is supported by gas exchange. Both kingdoms have developed respiratory anatomy in response to the arid life outside of the sea. Plants leaf stomata (figure 1) facilitate gas exchange, CO_2 uptake and O_2 release, between the environment and the inside of the plant. The stomatal pores are concentrated on the aboxial surface of a leaf in order to limit H_2O transpiration that occurs when said pores are open. Insects have a tracheal system for respiration. They use 10 pairs of spiracles (figure 2) along the lateral surfaces to inhale O_2 and exhale CO_2. The respiration occurs in discontinuous gas exchange cycles (DGCs) running in 14-minute repetitions. These DGCs consist of three parts: open phase with no external gas exchange; fluttering with O_2 uptake; and closed phase with CO_2 release. Both of these mechanisms can be impaired through using a substance to block air movement in or out of the respective pore. To determine the quantitative effects of such blocking, silicone jelly was used to coat the leaves of a *Vicia faba* and the spiracles of a *Blaberus gigantea*. The respiration of each species was then measured and compared to controls consisting of each organism with no jelly on it.

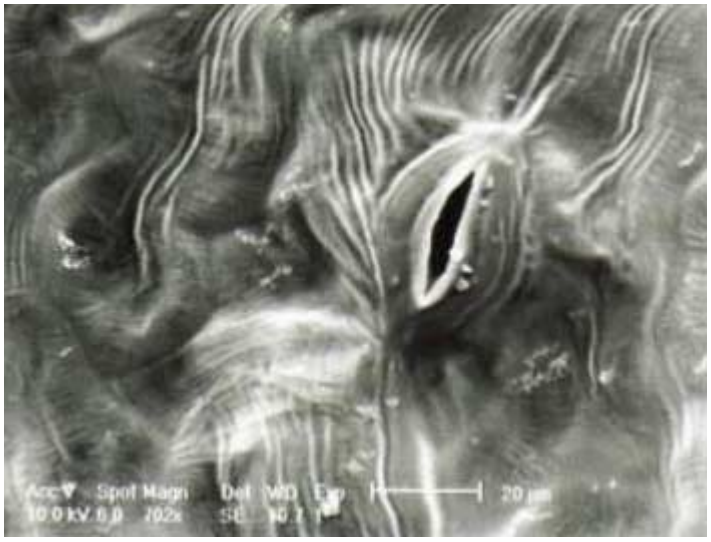


Figure 1: A stoma on the aboxial surface of a Vicia faba plant.

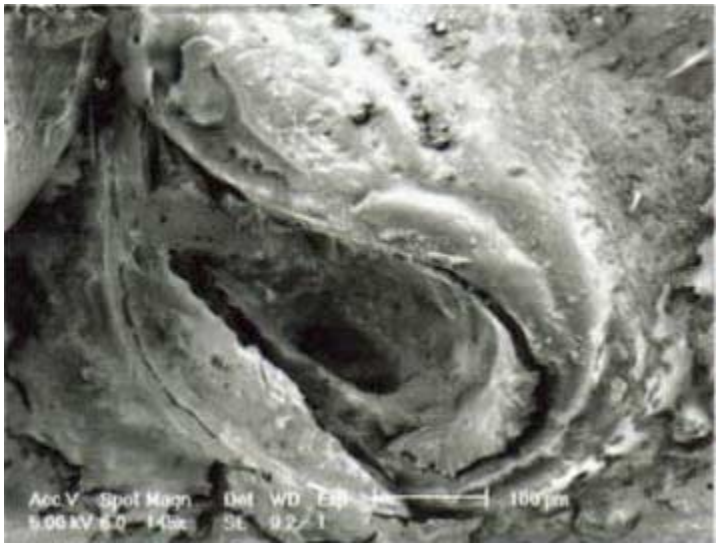


Figure 2: A spiracle of Blaberus gigantea

Hypothesis

The addition of a silicone lubricant will significantly inhibit plant and cockroach respiration. In addition, application to the underside of the leaf will reduce respiration more dramatically than an addition to the dorsal leaf surface and completely covering all

the posterior spiracles will compromise respiration more than application to the posterior spiracles of a single side.

Results

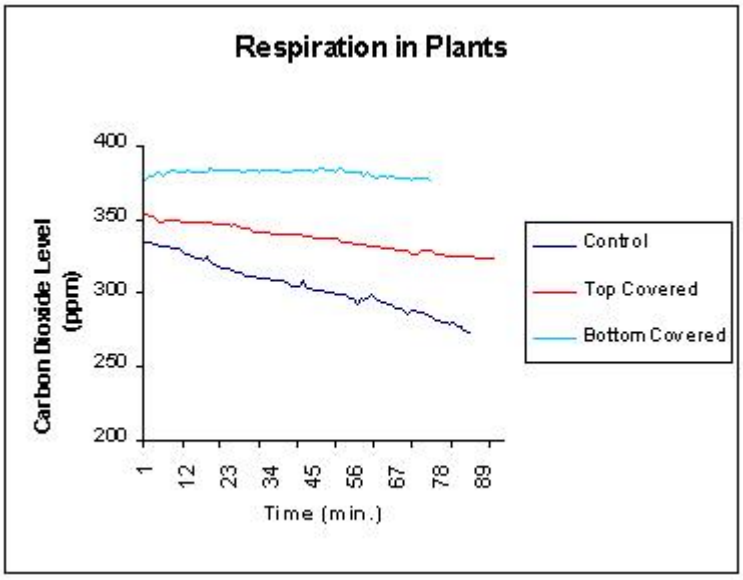


Figure 3: The respiration of Vicia faba over time in minutes. The respiration was measured three times: once with no silicone jelly coating (control), once with only the adoxial surface coated (top covered), and once with only the aboxial surface coated (bottom covered).

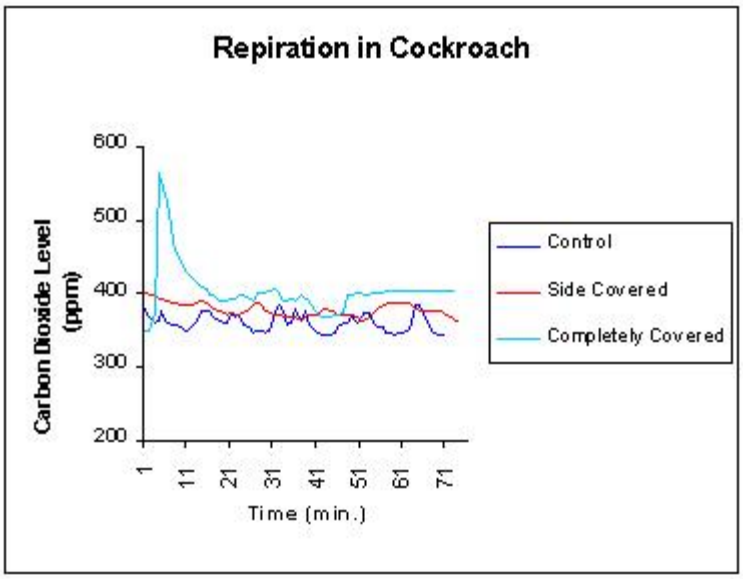
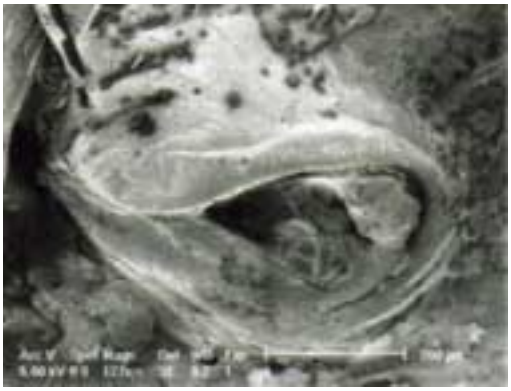


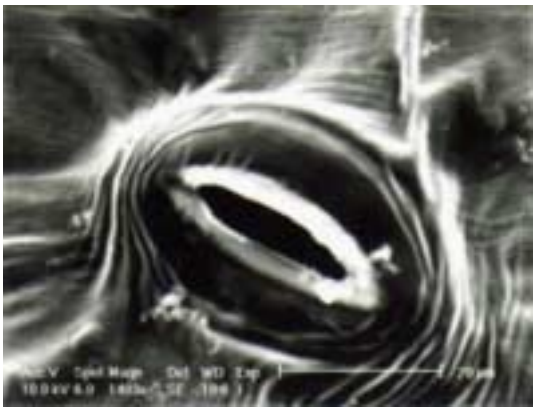
Figure 4: The respiration of Blaberus gigantea over time in minutes. The respiration was measured three times: once with no silicone jelly coating (control), once with only one side coated (side covered), and once with both sides coated (completely covered).

Interpretation

Silicone lubricant effectively reduced gas exchange in *Vicia faba* by obstructing the crucial respiratory openings. The control plants exhibited normal respiration as can be seen by the steady decline of [CO_2] in Figure 3. The [CO_2] for the control declined 60.746 ppm. When the adoxial surface was coated, the [CO_2] declined only 30.931 ppm. This shows that respiration did in fact occur but was severely impaired by having a surface unable to respire. When the aboxial surface was covered, the effect was much more pronounced as is demonstrated by Figure 3. The [CO_2] actually increased 0.153 ppm. This shows that the aboxial surface is much more important to respiration than the adoxial surface.

The silicone jelly coating likewise impacted the DGCs of *Blaberus gigantea*. The control had a DGC of about 18 minutes as is seen in Figure 4. When one side of the posterior spiracles were coated with the silicone jelly, the discontinuous gas exchanges continued, but they were slowed down by about half and did not closely resemble the control cockroach's DGCs. This shows that the coating did in fact limit respiration, but the other side of spiracles managed to maintain some sort of respiratory cycle. When all 6 pairs of posterior spiracles of the *Blaberus gigantea* were coated with the silicone jelly, respiratory activity became very erratic as seen in Figure 4. The [CO_2] initially spiked to 575 ppm most likely due to panic from the sudden loss of respiratory ability. No DGCs were clearly seen. In addition, the *B. gigantea* in question began exhibiting distress behavior not seen in the other experiments. The cockroach remained motionless and secreted a white chalky substance which was most likely some sort of alarm odor secreted from glands located in the walls of the tracheae close to spiracles. In conclusion, silicone jelly effectively obstructed respiratory pathways, handicapped crucial anatomy and consequently altered the respiration of *Vicia faba* and *Blaberus gigantea* .





Guthrie D.M., Tindall A.R. 1968. The Biology of the Cockroach. *The Physiology of Respiration*: 354-363

Lighton John. 1996. Discontinuous Gas Exchange in Insects. *Insect Ventilation*: 309-342

Campbell Neil A. 1996. Biology. 4th ed. Menlo Park: Benjamim/cummin Publishing Company, Inc.