The low pressure life of a worker bumblebee

Michael Stasiak, TechNote 003-2011

It is well known that pressurized environments would be required to sustain human life on other planetary bodies such as Mars or the Moon, and the use of plants to provide at least a portion of the life support needs is a likely scenario. Just like on Earth, plants are able to provide us with food, oxygen and carbon dioxide removal. As a bonus, in a closed environment plant transpiration can also provide a great deal of clean water.

Maintaining environments at atmospheric pressures at Earth ambient pressures (ie. 101kPa at sea level) has a high cost due to massive structural requirements. Reducing operational pressures would significantly reduce costs related to Moon or Mars habitat transportation and construction.

So where do the bees come in?

A number of the candidate crops selected for use in Advanced Life Support Systems (ALS) require insect pollination. This task can be performed by people involved in the ALS, but as systems become large, the work becomes onerous. Let's get the bees to do it. That's what they do.

Studies on radish here at the Controlled Environment Systems Research facility have shown growth and development is possible at pressures as low as 10kPa as long as there is adequate oxygen for respiration. It is likely that in the plant-pollinator relationship, the atmospheric requirements of the pollinators will be the limiting factor under conditions of reduced pressure

One of the CESRF hypobaric chambers was fitted with a hive of live bumble bees (*Bombus impatiens*). The hive was connected to a flight cage which contained two artificial flowers with a 30% sucrose solution. The bumblebees could travel freely between the hive and the flight cage, and were exposed to seven different atmospheric treatments daily for three days: 97 (ambient), 80, 70, 60, 50, 40, and 30kPa. The Atmospheric composition of gases was maintained equivalent to that of ambient pressure (~21 kPa partial pressure of oxygen). The treatments were video-recorded and were administered in a random order

each day. Exposure to each treatment lasted for 30 minutes and each video segment was viewed and a number of different variables were scored and recorded:

- the total number of visits to the flight cage
- the percentage of time bees spent foraging flying, walking and remaining stationary
- the level of control exhibited by bees in their take-offs and landings

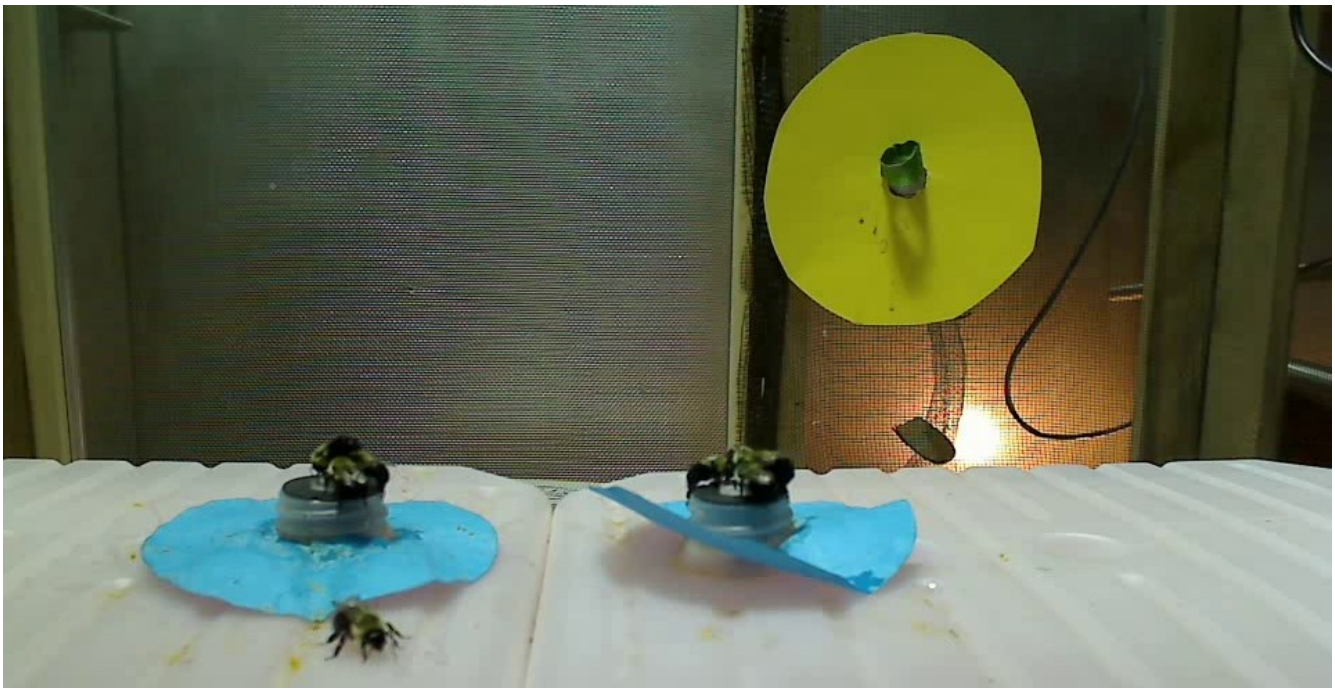

Figure 1: Bumble bees (Bombus impatiens) at feeding stations within the hypobaric chamber

The results for each treatment were averaged over the three days. In general, the results showed that with atmospheric total pressures of 50kPa or higher, the average number of bee visits to the flight cage was between 74 and 112 per hour, whereas treatments below 50kPa total pressure averaged fewer than 26 bee visits per hour. Similarly, the average percentage of time spent by bees foraging, flying, walking and remaining stationary was similar for treatments of 50kPa or higher, whereas when exposed to lower pressures, the bees spent much more time walking and remaining stationary and less time foraging and flying. Similarly, the take-offs and landings of bees were much more controlled and efficient during the treatments of 50kPa or higher, and less controlled during the lower pressure treatments.

Experiments conducted later demonstrated that maintaining an adequate partial pressure of oxygen was also crucial to bee deployment, with lower oxygen concentrations leading to reduced foraging.

This information was compiled from data presented at The 2011 Canadian Pollination Initiative conference in Guelph with a poster entitled 'Bees in space: the atmospheric requirements of bumblebees, Bombus impatiens, to be used as pollinators in a greenhouse on Mars' by Erika Nardone, Peter Kevan, Michael Dixon and Michael Stasiak.

Document: TechNote_003-2011.odt

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