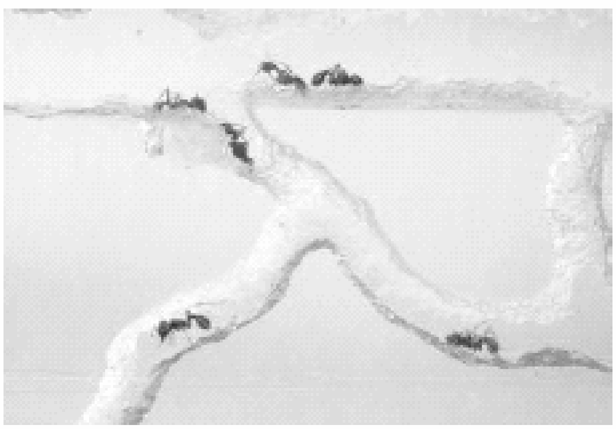
The Development and Testing of Visualization and Passively Controlled Life Support Systems for Experimental Organisms During Spaceflight

ANTS IN SPACE EXPERIMENT

Although the harvester ant, *Pogonomyrmex occidentalis* has been subjected to the microgravity environment during a series of parabolas on board the Novespace Airbus 300 in December 2000, no experiments have been conducted with these animals on orbit. The objective of this experiment is to observe and characterize the effects of space flight on the tunneling



behavior of harvester ants during a 16-day long space shuttle flight. Particular attention will be focused on the activity level of the ants and their social interactions. Upon their return, the ants and their tunnels will be examined and compared to an equivalent colony kept under similar environmental conditions on the ground. Laboratory experiments using the life support system design and methodology described below have verified that queenless ant colonies can be maintained for extended periods with no addition of food or water, and minimal gaseous exchange. Colonies have been maintained for over eight months in Globus International partner's laboratories and are still living at the time of this article. Upon completion of a successful flight test as provided by the STS-107 shuttle mission, a system will be complete that allows for long-duration maintenance of ants on orbit for months on ISS, with the possibility of use with other insect species. Experimentation with alternate insect species has not yet been done.

Hardware Design

The containment hardware for the ant experiment has external dimensions of approximately 11.113cm wide (4.375 inches), 1.27cm deep (0.5 inch), and 18.415cm in height (7.25 inches). The volume is composed of a larger rectangular area containing the agar/food gel, and a smaller side passageway providing an area for depositing tunnel material. A small space in the wall separating the two sections allows the ants to access the gel for tunneling. The vent slots on the outer sidewalls have a membrane cover, which will keep the ants inside while allowing air to enter the habitat and thus controlling the humidity. A small chamber or nest attached to the outer passageway keeps the ants from tunneling until they are released on-orbit by a crew-activated plunger mechanism.

Wetware and gel

Workers of the Harvester ant species *Pogonomyrmex occidentalis* will be placed into a single experiment enclosure. *P. occcidentalis* was selected, as it is a very hardy species, thriving in broad temperature and humidity ranges, and typically lives up to one year in the wild and have been maintained for eight months under laboratory conditions in the Globus International partner's facilities. Additionally, these ants are advantageous because they are large, allowing for good visualization of the ants, their behavior, and their large tunnels.

The tunneling medium is an agar-based gel. Numerous tests were performed with several types of standard captive ant tunneling media, such as sand, soil, pumice and vermiculite. With all of these media the tunnels risk collapse due to the vibration of landing, and tend to be prone to fungal infection if an ant dies within the habitat, or from food molding. The agar gel was chosen as the tunneling medium as it is firm enough to maintain integrity during launch and landing vibrations, and provides fungus and mold suppression through inhibitors in the gel. The gel is provided by Globus International partner's.

The ants tunnel through the gel in a similar manner to the way they would tunnel through sand, soil or other standard medium. The workers bite off pieces of medium and carry it out of the tunnel, placing it outside the tunneling medium area, as they would with pieces of sand. The gel is colored to provide contrast with the ants for easier visualization with the video. A starter tunnel of approximately 1cm in depth is provided in the gel to stimulate the ants to commence tunneling once inserted into the tunneling area of the habitat.

The agar gel contains sucrose to stimulate the ants to eat it. Amino acids, vitamins and minerals are added to the gel to provide an appropriate diet for the ants. As the agar gel is largely made up of water, the ants also receive all their water from the gel as they eat it. Both the metabolizing of the gel by the ants, and the evaporation of water from the gel provides humidity within the tunnels. Adequate ventilation in the habitat ensures that no water collects within the tunnels or habitat area.

Unlike the sealed systems based on the ABS design, the ant system depends on limited gas exchange with the cabin atmosphere for removal of CO_2, supply of Oxygen and removal of water vapor. Gas exchange occurs through Millipore brand 0.5-micron filter paper. Six openings of 6mm diameter each with a filter are distributed across the headspace of the system. Distributed openings reduce the chance that gas exchange will be precluded by the ants depositing gel over the openings.

The gel provides disease control by suppressing fungal and mold growth – the primary cause of death in captive colonies after desiccation. As the animals tunnel through the medium and eat it, the mold inhibitor contained in the gel eradicates mold and fungal spore, which also prevents the ants from being a source of infection in the case of the death of one of the workers.

Experiment Samples and Materials

Ten days prior to integration of the experiment into the GBA-ICM, the ants are placed onto a diet of agar gel, similar to the gel used for the flight medium. This ensures that the exterior of the animals' exoskeletons and their digestive tract, are free of fungal spore that could later contaminate the experiment on orbit.

Several hours prior to the final integration of the experiment payload for the shuttle launch, the harvester ants will be placed into an activation chamber, located within the experiment habitat, to maintain them separated from their tunneling material. A small amount of the agar gel is placed in the activation chamber to provide food and water for the time the ants remain within the activation chamber, which is expected to be

approximately 43 hours under a nominal launch scenario.
Once on orbit the activation chamber will be opened by a crewmember, thus activating the experiment and allowing the ants to have access to the experiment volume.
Video and still images are recorded daily of the ant habitat. Students at the participating schools maintain ground control habitats in their classrooms, and compare the ant tunneling and activity to that of images of the on orbit ant habitat. High fidelity ground control habitat is maintained within a GBA-ICM at the SPACEHAB Astrotech Facility at Cape Canaveral for the duration of the nominally 16-day Shuttle flight.
Three to four months prior to the launch date, a full ground-based experiment will be performed under flight like conditions within the GBA-ICM at BioServe to verify proper functioning of the hardware, wetware and protocols.

ACKNOWLEDGEMENTS
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REFERENCES
Patent 5865141. US Patent Office.