



A Miniaturized Video System for Monitoring *Drosophila* Behavior

This method allows monitoring the movement of many fruit flies in space simultaneously.

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Long-term spaceflight may induce a variety of harmful effects in astronauts, resulting in altered motor and cognitive behavior. The stresses experienced by humans in space — most significantly weightlessness (microgravity) and cosmic radiation — are difficult to accurately simulate on Earth. In fact, prolonged and concomitant exposure to microgravity and cosmic radiation can only be studied in space.

Behavioral studies in space have focused on model organisms, including *Drosophila melanogaster*. *Drosophila* is often used due to its short life span and generational cycle, small size, and ease of maintenance. Additionally, the well-characterized genetics of *Drosophila* behavior on Earth can be applied to the analysis of results from spaceflights, provided that the behavior in space is accurately recorded.

In 2001, the BioExplorer project introduced a low-cost option for researchers: the small satellite. While this approach enabled multiple inexpensive launches of biological experiments, it also imposed stringent restrictions on the monitoring systems in terms of size, mass, data bandwidth, and power consumption. Suggested parameters for size are on the order of 100 mm³ and 1 kg mass for the entire payload. For *Drosophila* behavioral studies, these engineering requirements are not met by commercially available systems.

One system that does meet many requirements for behavioral studies in space is the actimeter. Actimeters use infrared light gates to track the number of

times a fly crosses a boundary within a small container (3×3×40 mm). Unfortunately, the apparatus needed to monitor several flies at once would be larger than the capacity of the small satellite.

A system is presented, which expands on the actimeter approach to achieve a highly compact, low-power, ultra-low bandwidth solution for simultaneous monitoring of the behavior of multiple flies in space. This also provides a simple, inexpensive alternative to the current systems for monitoring *Drosophila* populations in terrestrial experiments, and could be especially useful in field experiments in remote locations. Two practical limitations of the system should be noted: first, only walking flies can be observed — not flying — and second, although it enables population studies, tracking individual flies within the population is not currently possible.

The system used video recording and an analog circuit to extract the average light changes as a function of time. Flies were held in a 5-cm diameter Petri dish and illuminated from below by a uniform light source. A miniature, monochrome CMOS (complementary metal-oxide semiconductor) video camera imaged the flies. This camera had automatic gain control, and this did not affect system performance. The camera was positioned 5–7 cm above the Petri dish such that the imaging area was 2.25 cm². With this basic setup, still images and continuous video of 15 flies at one time were obtained. To reduce the required data bandwidth by several orders of magnitude, a band-pass filter (0.3–10

Hz) circuit compressed the video signal and extracted changes in image luminance over time. The raw activity signal output of this circuit was recorded on a computer and digitally processed to extract the fly movement “events” from the waveform. These events corresponded to flies entering and leaving the image and were used for extracting activity parameters such as inter-event duration. The efficacy of the system in quantifying locomotor activity was evaluated by varying environmental temperature, then measuring the activity level of the flies.

The system presented in this work for monitoring fly activity is an inexpensive, compact, and ultra-low bandwidth alternative to currently available options, making it a suitable candidate for biological experiments on small satellites or field experiments. In contrast to most actimeters, multiple flies can be imaged in a small apparatus. Additionally, the flies are contained in a larger chamber (20 cm² vs., e.g., 1.2 cm²), which permits motion in two axes rather than one. This may allow the fly behavior to more closely approximate the natural state.

This work was done by Sharmila Bhattacharya of Ames Research Center; Omer Inan, Gregory Kovacs, and Mozziyar Etemadi of Stanford University; Max Sanchez of Lockheed Martin; and Oana Marcu of National Space Grant Foundation. Further information is contained in a TSP (see page 1).

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Hydrofocusing Bioreactor Produces Anti-Cancer Alkaloids

Enhancement of production may be attributable to favorable aggregation of cells.

Lyndon B. Johnson Space Center, Houston, Texas

A methodology for growing three-dimensional plant tissue models in a hydrodynamic focusing bioreactor (HFB) has been developed. The methodology is expected to be widely applicable,

both on Earth and in outer space, as a means of growing plant cells and aggregates thereof under controlled conditions for diverse purposes, including research on effects of gravitation and

other environmental factors upon plant growth and utilization of plant tissue cultures to produce drugs in quantities greater and at costs lower than those of conventional methodologies.