HENRY JP, BALLINGER ER, MAHER PJ, SIMONS DG. *Animal studies of the subgravity state during rocket flight*. JAM 1952; 23: 421–432. 1952.

This report described the first sub-orbital flights of animals used for study of physiological responses (respiration, circulation, and neurovestibular) during launch and weightlessness, matters of great interest as rocket aircraft were producing increased periods of weightlesness for their pilots. Earlier researchers (Gauer, Haber—1950) had predicted that long periods of weightlessness would result in neurovestibular dysfunction and disorientation, but did not anticipate any cardiovascvular or respiratory changes.

The experiments were carried out during the period 1948-1952 by the Aero Medical Laboratory at Wright-Patterson AFB, OH, using five V-2 and three Aerobee launches that provided a 3-5 g launch profile lasting 45 s followed by 2-3 min of microgravity. Some of these flights reached an altitude of 450,000 ft. The animals (a total of eight primates) were provided with life support and physiological data were downlinked by telemetry. The capsules from the first six flights were not recovered, but "satisfactory data were obtained up to the moment of impact." The last two Aerobee capsules were successfully recovered after landing by parachute. In Aerobee III, two anesthetized primates were used, one oriented so that launch acceleration was +Gz and the other +Gx. No changes were seen in respiration, pulse, venous pressure, or EKG, and no meaningful differences were observed between the +Gz and +Gx orientations. A slow decrease in the systolic and diastolic blood pressure was noted in the instrumented primates during weightlessness. The signifigance significance of that for longer periods of weightlessness would have to wait for future investigations.

On the last V-2 flight and Aerobee II and III, mice were photographed in several environments to study the neurovestibular effects. On the V-2, a single mouse in a wire cage with firm footholds displayed disorientation and no concept of up, but was able to remain oriented after clinging and showed no lack of coordination. The two Aerobee flights had a electrically driven rotating drum to deprive the mice of all tactile and visual orientation. On Aerobee II, a labryinthectomized mouse was compared to a normal mouse in a separate compartment. It was predicted that the labryinthectomized mouse would have less disorientation as they were pre-adapted to the absence of vestibular cues, and this appeared to be the case. The normal mouse was more disoriented, but remained coordinated. On Aerobee III, one rotating drum had no footholds and the mouse showed violent disorientation during weightlessness. A mouse in the drum with a foothold showed initial disorientation, but then clung to the foothold and remained still while riding the drum. All mice in all flights showed normal orientation and coordination after parachute opening. In summary, there was an initial state of disorientation to weightlessness, but the animals were able to maintain control if allowed a foothold and showed no lack of coordination.

BACKGROUND

The first animals sent into space were actually fruit flies launched aboard a V-2 rocket in 1947 to explore the genetic effects of radiation exposure at high altitudes. Some further V-2 missions carried additional biological samples, including corn seeds and moss.

After the suborbital flights described in this paper, primates were not launched again until on December 13, 1958, when Gordo (also called Old Reliable), a squirrel monkey, initially survived being launched aboard a Jupiter rocket. Telemetry data sent back during the flight showed that the monkey survived the 10 g of launch, 8 min of weightlessness, and 40 g of reentry, although he died when the parachute failed.

On May 28, 1959, Able, a rhesus monkey, and Baker, a squirrel monkey, rode in the nosecone of a Jupiter launch vehicle to an altitude of 360 mi (579 km) and a distance of 1,700 mi (2,735 km). They withstood 38 g and were weightless for about 9 min. A top speed of 10,000 mph (16,000 km/h) was reached during their 16-min flight. The monkeys survived the flight in good condition. Able died four 4 d after the flight from a reaction to anesthesia while undergoing surgery to remove an infected medical electrode. He was preserved and is now on display at the Smithsonian Institute of Air and Space Museum. Baker lived until November 29, 1984, and is buried on the grounds of the U.S. Space and Rocket Center in Huntsville, AL.

Goliath, a squirrel monkey, died in the explosion of his Atlas rocket on November 10, 1961. A rhesus monkey called Scatback flew a suborbital flight on December 20, 1961, but was lost at sea after landing.

In 1959, Sam, a rhesus monkey, flew on the Little Joe 2 in the Mercury program to 53 mi high. Miss Sam, also a rhesus monkey, followed in 1960, on Little Joe 1B, although her flight was only to 8 mi (14 km) in a test of emergency procedures. Ham, a chimpanzee, was launched on a suborbital flight in Mercury-Redstone 2 on January 31, 1961. Ham had been trained to pull levers to receive rewards of banana pellets and avoid electric shocks. Enos, another chimpanzee, became the first nonhuman primate in orbit on November 29, 1961, on Mercury-Atlas 5.

The United States was not alone in studying animals aboard rockets. During the same period, the Soviet rocket pioneer Sergei Korolev and his biomedical expert Vladimir Yazdovsky used mice, rats, and rabbits as one-way passengers for their initial suborbital tests. On January 29, 1951, the Soviet Union launched the R-1 IIIA-1 flight carrying two dogs, Tsygan (Russian: Цыган, or "Gypsy") and Dezik (Russian: Дезик) in a ballistic trajectory that both survived. Another such flight later that year provided data but had a fatal outcome; it is said that Korolev was devastated by the loss of the two dogs, Dezik and Lisa. Several other successful short suborbital launches of dogs occurred immediately after this.

The first animal in orbit was the dog Laika, launched aboard the Soviet Sputnik 2 spacecraft on November 3, 1957, in a capsule that was not designed for recovery. On August 12, 1960, Sputnik 5 (also known as Korabl-Sputnik 2) carried the dogs Belka and Strelka, the first spacecraft to carry mammals into orbit and return them alive. One of Strelka's pups, Pushinka, bred and born after her mission, was given as a present to Caroline Kennedy by Nikita Khruschev in 1961, and has many descendants.

The importance of this Classic can not be overstated. It describes the first launch and successful recovery of animals in suborbital flight and the first demonstration of telemetry for physiological data. These pioneering observations of physiology during launch and sustained weightlessness indicated that there were no immediate biomedical barriers to spaceflight and that the cardiopulmonary and neurovestibular effects would be tolerable. However, the authors recognized that much longer periods of weightlessness in orbit might produce cardiovascular changes not apparent in these relatively brief exposures.

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