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Review Article

Review of the History of Animals that Helped Human Life and Safety for Aerospace Medical Research and Space Exploration

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ABSTRACT In 2019, the Aerospace Medical Association of Korea celebrated its 30th anniversary. On the other side of the world, it was also the 62nd anniversary of Russian launch Sputnik 1 of the world's first artificial satellite on October 4, 1957. In additionally, the world, especially the United States was shocked, when on November 3, 1957, Sputnik 2 blasted into Earth orbit with a dog named "Laika"; it was the role of veterinarian's activities for aerospace medical research and exploration. Veterinarians (Vets) are responsible for the health of all the animals for aerospace medicine whether on the ground or in space. Vets can enhance animal and public health and this knowledge of Vets and astronauts can extend their mission durations, go to nearby Earth Asteroids, Mars and other heavenly bodies to study their living and non-living characteristics. This review article is the brief history of the original growth of the veterinarian's activities for the aerospace medical research, in order to stimulate future strategies for improvements in the space life sciences and exploration.

Keywords: Veterinarians, Animals, Aerospace medicine

I. INTRODUCTION

In 2019, the Aerospace Medical Association of Korea celebrated its 30th anniversary, its beginning seems like it was only yesterday [1]. On the other side of the world, it was also the 62nd anniversary of Russian launch Sputnik 1 of the world's first artificial satellite on October 4, 1957 [2-5]. In additionally, the world, especially the United States was shocked, when on November 3, 1957, Sputnik 2 blasted into Earth orbit with a dog named "Laika"; it was the role of veterinarian's activities for aerospace medical research and exploration [2-5].

Today's Veterinarieans (Vets) are the doctors educated to protect the health of both animals and people. They work hard to address the health and welfare needs of every species of animals. Vets also play critical roles in environmental protection, biomedical research, food hygiene and safety, public health, and the aerospace and deep-sea medicine in uniformed (military) service [6-9].

Vets are responsible for the health of all the animals for aerospace medicine whether on the ground or in space. When a space shuttle experiment involving animals as the bioastronautics is scheduled, a Vet is consulted to ensure that the animals selected are appropriate for those experiments [8]. They also provide instructions for proper care of the animals during the voyage, including information on how to avoid unacceptable treatments or procedures. At the National Aeronautics Space Administration (NASA)

Table 1. Review of the brief history of animal researches that helped human life and safety for aerospace medical research and space exploration, the 1950s~2000s

Schedule	Carried	Subjects	Experiments
Early Stage; vertebrate animals into space exploration			
Jun/14/1949*	V-2 rocket; 134 km	Rhesus monkey; "Albert II".	Monkey; attained an altitude of 83 miles: died on impact after a parachute failure.
Sep/20/1951	Aerobee; missile	Monkey; "Yorick" & 11 mice	Monkey and 11 mice; the flight of 236,000 ft. As the first monkey to live through a space flight.
Jul/22/1951*	SOVIET; R-1: IIIA-1	Two dogs (Tsygan & Dezik)	The first living and higher into space, but not into orbit.
May/22/1952	Aerobee; missile	Two Philippine Monkey (Patricia & Mike) and 2 mice	Monkeys; rapid acceleration. Fired 36 miles up at a 2000 mph to reach a high altitude. Also on this flight were two mice.
1951~1952	SOVIET; R-1 Rocket	Nine dogs	Carried nine dogs altogether, with three dogs flying twice that recovered by parachute.
1948~1954	V-2 rockets; Eight times/ Suborbital flights	Monkeys and mice	Telemetric recording of physiological measurement of mice & monkeys; to study the influence of high g-forces and micro-gravity on the cardiovascular system. In addition, the behavior of mice was recorded with a movie camera.
1950~1954	Balloon flight; 27~30 km/ Alti. Up to 28 hrs.	Monkeys, hamsters, dogs, cats, mice & Fruit flies	The effects of the thin atmosphere and radiation.
1951~1954	Aerobee 71 km/altitude	Rh-monkey, mice	Rh-monkeys and mice were flown to study the effects of cosmic radiation and changes in the cardiovascular system.
1951~1952	Aerobee; 71 km/Alti.	Rh-monkeys, mice	The effects of cosmic radiation and changed in the cardiovascular system.
Nov/3/1957*	SOVIET; Sputinik-2	Dog; "Laika"	A dog named "Laika" blasted into Earth orbit. She was hastily trained and put aboard in metal carriers under the second Sputnik sphere. Sputnik finally burned up in the outer atmosphere in April 1968.
Jul/9/1958	Jupiter missile	Monkeys.	Two monkeys; a 30-mile altitude, and both recovered unharmed.
Dec/13/1958	Bioflight-1; (Jupiter rocket) 480 km	Gordo, the squired monkey.	Effects of heart rate & sounds, body temp, pressure & radiation monitored.
May/28/1959	Bioflight-2 (Jupiter rocket) 480 km	Rh-monkey "Abel"& Squirrel monkey: "Baker".	The electromyogram test. Abel was trained to tap a switch when a red-fleshed, to collect on performance.
Dec/4/1959	Joe rocket. Speed: 3,685 mph/min.	Rh-monkey "Sam"	Test for alive in highly seed fight; 1 minute into the flight, a speed of 3,685 mph. After attending an altitude of 51 miles, with no ill effects from his journey.
Jan/21/1960	Joe rocket. Flight to 84 km altitude	Rh-monkeys	Rh-monkey Sam and Miss Sam on the second flight; verification of Mercury life support equipment.
ATLAS (USA): Survival tests in space			
1960	Atlas rocket; 650 km/Alti.	Mice	Three mice flight in space; effects of alive.
VOSTOK (Soviet): The first human to journey into space			
Apr/12/1961	Vostok-1	Man: Yuri A Gagarin.	The first human to journey into space. His capsule completed on-orbit of Erath.

Table 1. Continued 1

Schedule	Carried	Subjects	Experiments
MERCURY (USA); Initiated to demonstrate that human can survive in space			
Jan/31/1961	Mercury-2	Chimpanzee (Ham)	A suborbital flight, Chimpanzee Ham was closely monitored for the cardiovascular responses. It is the first initial suborbital flight in space.
May/5/1961	Mercury-3; Rocket 259 km/Alti.15 minutes	Man: Alan B. Shepard	The First suborbital flight of man; monitoring the physiological responses of astronaut American.
Nov/29/1961	Mercury-5; Atlas-E rocket; 183 minutes	Chimpanzee	Chimpanzee Enos became the first chimp to orbit the earth and he was recovered in excellent condition.
Feb/20/1962	Mercury-6; (Atlas rocket). 4 hrs 55 min.	Man: John Glenn	First orbital flight of American astronaut. The physiological responses of the astronaut were monitored.
FRANCE: The first cat and pig-tailed macaque into space exploration			
Oct/18/1963*	AGI rocket-47;	Cat. "Félix"	Cat, named Félix the first cat into space. Recovered alive after a 15 min for 130 miles flight.
Mar/7~13/1967	Vesta rocket	Two Pig-tailed Macaque (monkey): "Martine" and "Pierrtte"	These suborbital flights reached 243 km (151 mi) and 234 km (145 mi), respectively Martine became the first monkey to survive.
SOVIET; Experiment research for radiation effects in space exploration			
Feb/22/1966	SOVIET; Cosmos-110.	Two dogs."Veterok" and "Ugoyok"	Two dogs; named "Veterok" and "Ugoyok" were radiation effects: 21-day in space still stands as a canine record.
GEMINI: Growth experiments of Frog eggs in space, and tortoises to the Moon.			
Mar/16/1966	Genini-8; 10 hrs 41 min.	Frog eggs	First docking in space, Frog egg growth-experiment.
Nov/11~15/1966	Gemini-12; 3EVA's. One lasting 5 hrs.	Frog eggs	Frog egg growth-experiment.
Sep/14/1968*	SOVIET; Zond-5, Circumlunar voyage	Two tortoises	The first animals in deep space, the first to circle the Moon, and the first Horsfield's tortoises. The first inhabitants of Earth to travel around the Moon.
BIOSATELLITE; Earth-orbital missions to biological processes in space by the U.S			
Jun/28~Jul/7/69	Biosatellite-III	Monkey; pig-tailed-macaque	Mission terminated after nine days due to bad health of monkey (panned for 30 days). Study of a monkey. The mission's objective was to investigate the effect of spaceflight on brain states, behavioral performance, cardiovascular status, fluid and electrolyte balance, and metabolic state.
Apollo 11: The first landed humans on the moon			
July/20~24/1969	A Saturn V- Rocket; Apollo-11: Columbia	Man: Neil Amstrong, Buzz Aldrin, and Michael Collins	Apollo 11 was the spaceflight that first landed human on the moon. Armstrong's first step on to the lunar surface was a worldwide audience on July 20, 1969 at 20:17 UTC.
APOLLO; Biomedical experiments requiring no or only small additional hardware items were flown			
Dec/7~19/1972	Apollo-17; Sixth and last lunar landing	Five-pocket mice	BIOCORE, five pocket mice were flown to study HZE radiation effects.
APOLLO-SOYUZ (ASTP); The first rendezvous and docking of American and Russian spacecraft			
Nov/9~15/1970	Orbiting; Otolith-A.	Two Bullfrogs	Upon entering microgravity several changes in vestibular responses of the bullfrog were noted. All observed changes were back to normal during the last 10-20 hours of the space flight.

Table 1. Continued 2

Schedule	Carried	Subjects	Experiments
COSMOS-SOVIET; A biosatellite was a missions to biological Ex. in unmanned, launched in 1966			
Nov/25~15/1975	Cosmos-782; 20 days	Rats, fruit flies and killifish eggs	Immunology & musculoskeletal adaptation as well as radiation effects on animals.
Aug/3~22/1977	Cosmos-936; 19 days	Rats and fruit flies	Effects on biological stems and outcomes radiation. Usage of centrifuge as a countermeasure to microgravity.
Sep/25~Oct/14/1979	Cosmos-1129 19 days	Rats and Japanese quail	Radiation; mammalian reproduction and embryogenesis in space.
Dec/14~19/1983	Cosmos-1514 Five days	Rh-monkeys & rats	Circadian rhythms in Rh-monkeys and morphological development of rat fetus.
Jul/10~17 1985	Cosmos-1667 Seven days	Rh-monkeys	Cardiovascular and cardiopulmonary Adaptation processes in Rh-monkeys
Sep/29~Oct/12/1987	Cosmos-1887 13 days	Rh-monkeys	Effects on the biological system in rats and quantitative analysis of skeletal changes in primates.
Sep/15~29/1989	Cosmos-2044 14 days	Rh-monkeys & rats	Effects of spaceflight on circadian rhythms, temperature regulation and metabolism as well as neuromuscular adaptation in Rh-monkeys. And to repeat the rat analyses on Cosmos-1887.
Dec/29/1992~Jan/10/1993	Cosmos-2229 13 days	Rh-monkeys	Bone, neuromuscular and vestibular Physiology circadian rhythms/meta-holism, two Rh-monkeys served as experimental subjects.
SPCE-SHUTTLE; The world's first reusable spacecraft & the US vehicle having a standard sea-level atmospheric pressure composition			
Aug/30~Sep/5/1983	STS-8; Challenger, TDRS-deploy	Rodents	Extensive monitoring of fluid shifts vesicular/neurosensory changes, rodent studies.
Apr/6~13/1984	41-C; First Satellite repair.	Rodents	Gravitational biology studies using rodents.
Apr/29~May/6/1985	51-B; Spacelab-3	Rodents and small primates	Tests of Research Animal Holding Facility for rodents and small primates, visual observations confirmed motion sickness in primates, experiments in exercise and fluid-loading as countermeasures for cardiovascular reconditioning.
Mar/13~18/1989	STS-29; TDRS-D	Rodents & chicken	Chromosome and plant cell division experiment, protein crystal growth and rodent bone- Healing experiment, chicken embryo development.
Oct/6~10/1990	STS-41; Ulysses	Rodents	Orthostatic function tests during entry, landing and egress, postural equilibrium control tests during landing and egress, visual-vestibular integration studies, gravitational-biology studies.
Jun/5~14/1991	STS-40; SLS-1.	Human & rodents	First space mission dedicated to biological research, exams. In cardiovascular, cardio-pulmonary, neurovestibular, muscle and bone physiology in both human and rodent subjects.
Sep/12~18/1991	STS-48	Rodents	Gravitational-biology studies with rodents, radiation monitoring and studies of cosmic radiation effects.
Sep/12~20/1992	STS-47; Spacelab-J	Animals & human	Ex. Investigating human and health, cell separation, developmental biology for animal and human physiology and behavior, radiation and biological rhythms.
Jan/13~19/1993	STS-54; TDRS-F	Rodents	Gravitational biology studies, evaluation of cardiovascular and musculoskeletal deconditioning on rodents.
Apr/8~17/1993	STS-56; ATAS-2 Spartan 201	Rodents	Physiological and anatomical studies on rodents, tissue loss and radiation effects.
Jan/8~23/1994	STS-65; IML-2	Aquatic animals	Gravisenory test of aquatic animals, rotating centrifuge (Hypogravity Exams), spinal changes in humans and LBNP.
Sep/30~Oct/11/1994	STS-64; SRL-2	Insects (spiders)	Radiation monitoring, physiological- Processes in insects such as spiders, centipedes and crustaceans.

Table 1. Continued 3

Schedule	Carried	Subjects	Experiments
Jul/13~21/1995	STS-70; TDRS-G	Rats, Medaka embryos & plant	Radiation monitoring, effects of micro-gravity on embryogenesis of rats and Medaka embryos, plant growth and development.
Jan/11~20/1996	STS-72; SFU retrieval	Rodents	Macromolecular tissue samples, effects of microgravity on rodent development and metabolism.
May/19~29/1996	STS-77; Spacelab-4 Spartan	Rats and plants	Immune system of the rat, production of pharmaceutical revenant substances in plants and effects of space flight on anthropoid and plant spaces.
Jun/20~Jul/7/1996	STS-78; Life & microgravity Spacelab: Life & Microgravity. Space Shuttle	Human, rats, and plants	Musculoskeletal experiments, research in metabolic, pulmonary and neuroscientific areas, investigations concerning human behavior and performance in space. Also biology Ex. In investigating bone loss in rats and lignin formation in plants.
During the 1990s~2000s	STS-90; Neurolab. Space Shuttle	Rats, mice, crickets, snail, two kind's fish and men: the crew members themselves	Neurolab was a Spacelab module mission for the effects of microgravity on the nervous system. In the here, one of the astronauts, Dr. R.M. Linnehan, DVM has two spaceflights, and has veterinary mission specialist for aerospace medical research logged more than 58 days in space shuttle [4,7,8,15].

Remarks: the raw data were collected and modified from the references [3-4,8-15].
*The first bioastronauts activities of each animal into space exploration.

headquarters, the duties of Vets include monitoring the health of research animals, planning and conducting experiments, collecting data/measurements, interpreting the results of their research, and writing reports on their finding for NASA [3,4,8-11].

Vets can enhance animal and public health and this knowledge of Vets and astronauts can extend their mission durations, go to nearby Earth Asteroids, Mars and other heavenly bodies to study their living and non-living characteristics [2,3,6,9].

In this present review, we go over the brief history of the original growth of the veterinarian's activities for the aerospace medical research, in order to stimulate future strategies for improvements in the space life sciences and exploration.

II. BODY

1. Animals that helped human life and safety in space exploration

In the earlier days of space exploration, nobody knew if people could survive a trip away from Earth, so using animals was the best way to find out [3,4,8,9]. Nonetheless, before humans actually went into space, one of the prevailing theories of the perils of space flight was that humans might not be able to survive under long periods of weightlessness. Over the last century, American and Russian scientists utilized animals - mainly monkeys, chimps and dogs - in order to test each country's ability to launch a living organism into space and bring it back alive and unharmed [3-6,9-11].

However, despite losses, these animals have taught the scientists a tremendous amount more than could have been learned without them. A wide variety of non-human animals have been launched into space, including monkeys, dogs, cats, mice, tortoises, and insects. The United States launched flights containing monkeys and primates primarily between 1948~1961 with one flight in 1969 and one in 1985. France launched one cat carrying flight in 1963. The Soviet Union and Russia launched monkeys between 1983 and 1996 [3,11-13]. During the 1950s and 1960s, the Soviet space program used a number of dogs for suborbital and orbital flight [13]. Two tortoises and a variety of insets were the first inhabitants of Earth to circle the Moon, on the 1968 Zond-5 mission, and five mice traveled in the orbiter of the 1972 Apollo 17 Moon mission [13]. On the other hand, STS-78 was the fifth dedicated Life and Microgravity Spacelab mission for the Space Shuttle program, flown partly in preparation for the International Space Station (ISS) project. The mission used the Space Shuttle Columbia launch pad 39-B on June 20, 1996, and the mission duration was 16 days, 21 hours in the space [14]. Moreover, STS-90 Neurolab was a 1998 Space Shuttle mission flown by the Space Shuttle

Columbia. The 16-day mission marked the last flight of the European Space Agency's Space-laboratory module [15]. Table 1 reviews the brief history of animals' help on human life and safety for the aerospace medical research and space exploration, the 1950s~2000s.

2. Bioastronautics' mission of vertebrates' for aerospace medical research into the space life and exploration

The bioastronauts of animal astronauts' in space served to test the survivability of spaceflight before human spaceflight was attempted. Later, other non-human animals were flown to investigate various biomedical processes and the effects that microgravity and spaceflight might have on them [3-8,11]. Since the very beginning of space exploration, vertebrate animals have been used in space exploration programs. Albert II, a Rhesus monkey, became the first monkey in space on 14 June 1949, in a U.S.-launched V-2, after the failure of the original Albert' s mission on ascent. Albert II reached about 83 miles [11], as shown in Table 1. On the other hand, on 22 July 1951, the Soviet Union launched the R-1 IIIA-1 flight carrying the dogs (Tsygan and Dezik) in space, but not orbit [11,12]. On 3 November 1959, the second-ever orbiting spacecraft took the first animal into orbit, the dog "Laika" [11,13]. On 18 October 1963, France Launched Felicette the cat named Félix aboard Véronique AGI sounding rocket No. 47. The launch was directed by the French Center d' Enseignement et Recherches de Medicine Aeronautique (CERMA). Felicette was recovered alive after 15 minutes of a 130 miles flight and a descent by parachute; she was monitored with electrodes implanted into her brain and recorded neural impulses were transmitted back to Earth [11,14]. The first animals in deep space, the first to circle the Moon, and the first two tortoises in space were launched on Zond-5 on 14 September 1968 by the Soviet Union. The Horsfield's tortoises were sent on a circumlunar voyage to the Moon along with flies, mealworms, and other biological specimens. These were the first inhabitants of Earth to travel around the Moon. The capsule overshot its terrestrial landing site but was successfully recovered at sea on 21 September. The animals survived but suffered from weight loss [11]. Nevertheless, in September 2007, during the European Space Agency's FOTON-M3 mission, tardigrades, also known as water-bears, were able to survive ten days of exposure to open-space with only their natural protection [9,11]. It was a landmark for vertebrates' bioastronauts in space life sciences research and exploration.

III. CONCLUSION AND RECOMMEND

Veterinarians' activities in aerospace medical research and astronauts can extend their mission durations, go to nearby Earth Asteroids, Moon, Mars and other heavenly bodies to study their living and non-living characteristics [2-4,8-15]. There is a strong relationship between the field of aerospace medicine and veterinary medicine including biomedical activities which can improve the techniques in the laboratory for space life research.

On the other hand, October 10, 2019, the Korea Aerospace Research Institute (KARI) celebrated its 20th anniversary [16]. It is our pleasure to personally recommending that the KARI has the potential for collaboration with the Aerospace Medical Association of Korea (ASMAK) in many areas including aerospace medicine and space life science, and human space flight and exploration. There is a bright future should the National Aeronautics and Space Administration of Korea (NASAK) be established for the National Projects of the Space life research and Exploration.

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CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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