Rabbits On Mars: One Giant Leap

Thomas Gangale
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Abstract

It goes without saying that permanent human settlements on Mars will need to grow their own crops, and there is a considerable body of literature that speaks to these issues. The need for farm animals should also be investigated.

While human waste will certainly be used to fertilize the Martian regolith, it also presents health concerns that will either need to be addressed by sewage treatment systems, or by exposure to the ambient environment, in order to eliminate pathogens. Sewage treatments systems will be expensive to transport, and an unknown period of exposure to Martian conditions will be required to render human waste safe for reuse. Selection of an animal species to accompany humans to Mars could address these concerns. The optimum Martian farm animal will have the following characteristics:

1. is well-characterized under laboratory conditions.
2. is small, and is therefore easy and inexpensive to transport to Mars.
3. has a short gestation period and a high number of births per pregnancy, therefore breeds rapidly from a small initial stock.
4. produces good quality manure.
5. requires low maintenance (fastidious, self-cleaning).
6. consumes most of the vegetable material that is inedible to humans, thereby accelerating the composting process and reducing the need for biomass processing equipment.
7. poses a near-zero health risk to humans.

These qualities describe *Oryctolagus cuniculus*, the European or domestic rabbit.

This presentation briefly reviews the history of the rabbit in space flight and suggests a program of future missions to study its adaptability to powered flight, microgravity and Mars gravity. Possible roles for the rabbit in Mars colonization are discussed. Preliminary results of experimentation with growing food in Mars soil simulant JSC Mars-1 enhanced with rabbit feces are also reported.

Characterization

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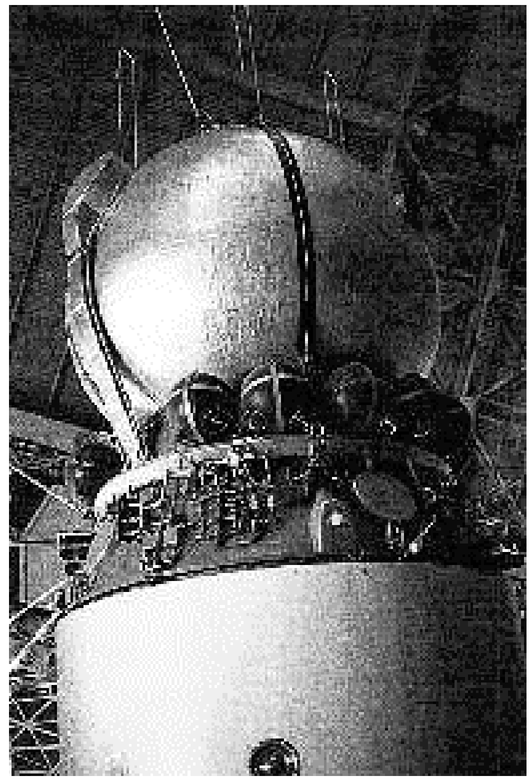
The European or domestic rabbit, and in particular the New Zealand White breed, is of course ubiquitous in research laboratories. Its physiology is well characterized in reference texts (Harkness &Wagner), (Weisbroth), (Hillyer), as is its behavior both in the wild (Lockley) and in the home (Harriman). The huge volume of baseline data is one factor that makes the rabbit an attractive subject for study in space.

History

On 19 August 1960, the Soviet Union launched an unmanned Vostok precursor mission known as Korabl Sputnik 2. Aboard were a gray rabbit, two dogs, 40 mice, 2 rats, 15 flasks of fruit flies, and plants. The spacecraft was recovered after 26 hours. This was the first recovery of the Vostok program; indeed, it was the first recovery of a Soviet spacecraft. The rabbit and other passengers were the first life forms ever to return from Earth orbit. So far, I have been unable to find reference to any other space flights involving rabbits. It would seem that this field of study is wide open.

The Great Recycler

Rabbits can play a significant role in rapidly introducing biomass to the Martian regolith and developing fertile soil. Rabbits consume most of the vegetable material that is inedible to humans. The cecum, which is the blind end of the colon, contains symbiotic microorganisms that produce cellulase to break down the cellulose walls of plant cells (McLaughlin). Undigested fiber and waste (hard fecal pellets) pass through the large intestine along with vitamin-rich cecotropes (soft cecal pellets), which are formed from fermented cecal material (Cheeke). Processing this biomass in the gut of the rabbit will reduce the need for mechanical systems to support similar functions. The less equipment we drag along to Mars, or the less we need to operate and repair it, the better.



Take, for instance, a grain crop such as oat. We humans just eat the inside of the seeds. Rabbits eat the whole plant.

Low Cost, High Return

At and average mass of about 3 kilograms, the rabbit is one of the smallest of domesticated mammals. Thus, rabbits and associated support equipment and supplies can be launched at probably about an order of magnitude less cost than more conventional farm animals such as cattle, sheep, and swine. Furthermore, only a small number of rabbits will be needed to start a colony on Mars. The ability of rabbits to proliferate is proverbial, but let's do the numbers.

Harkness & Wagner gives the average litter as seven to eight, while Weisbroth, et al., puts the average litter size as six to seven for a large number of breeds. Harkness & Wagner give the optimal breeding age as being between four-and-a-half months and three years. While the average gestation period is 31 to 32 days, so that theoretically one doe could have 11 litters in a year, Harkness & Wagner states that "an intensive breeding program, requiring good management, will result in up to 8 litters per doe per year." Also, Harkness & Wagner gives 47% as the ratio of females born per litter, while Weisbroth, et al, cites a study in which 48.6% females were obtained.

Allowing for some infant mortality and the slightly lower number of females born compared to males, the average litter should produce three females which will reach maturity. With the average litter being born at one-and-a-half month intervals, these females will take three such cycles to mature and will themselves produce litters beginning with the fourth cycle.

Thus, were one to begin with one unneutered male and one unspayed female rabbit on January 1, one would have a litter of three females and three males in early February, for a total of eight rabbits, including the parents. There would be another litter of six by the end of March, another in mid-May, and still another by the end of June, for a total of 26 rabbits. At this point, the three females from the first litter are ready to breed along with their mother, and so the four females will produce 24 rabbits in August, for a total of 50 rabbits.

Now the three females from the second litter mature, joining their mother and three older sisters, and the seven females produce 42 rabbits by the end of September, for a total of 92 rabbits. By November ten females are producing litters, adding 60 new babies to the population, for a total of 152. Finally, by the end of December, 13 females will give birth to 78 bunnies, swelling the population to 230 at the end of the first year.

Please don't try this at home!

Now, this numbers game started with just a single breeding pair. Obviously, to ensure a robust gene pool, we would take a few more rabbits than that to Mars. The important point is that the short gestation period and high birth rate per pregnancy greatly leverages the launch mass allocated to establishing this species on Mars.

Low Health Risk of Humans

There are very few diseases that rabbits can transmit to humans, and these are virtually unheard of in domestic populations. Standard quarantine procedures prior to launch will assure that a disease-free population is transported to Mars.

One human health concern is allergic reaction. Typically this manifests in the form of upper respiratory symptoms, but in many cases these symptoms should be controllable through medication.

Another concern is the potential for rabbits to inflict wounds on humans. Contrary to popular belief, they are not just harmless little bunnies. They can be aggressive. As with any relationship, there must be understanding and trust between humans and rabbits. In any case, rabbit bites and scratches can hardly be considered a dire threat, and there might be a case to be made for the occasional low-level stressing of the human immune system in maintaining long term health.

High Companionship Value

With regard to interaction with humans, the natural behavior of the rabbit gives it several advantages over other animals that might be considered for transplantation on Mars.

Rabbits are very fastidious. They groom themselves and each other. Thus their scent is inoffensive to humans. Rabbits are quiet. They don’t bark, howl, meow, moo, crow, or cackle. This is an important consideration, since humans and rabbits will live together in close quarters.

Rabbits are affectionate. Like humans, they are social animals, and have an instinctive need for companionship. The number of pets that are maintained in urban and suburban households throughout the world, for no other reason than for companionship, eloquently bespeaks the human emotional need to have animals around us. They are part of our natural environment. The growing practice of pet therapy in nursing homes and other institutions is further evidence of the importance of animals to the emotional health of humans living in conditions of isolation.

Project LEPUS

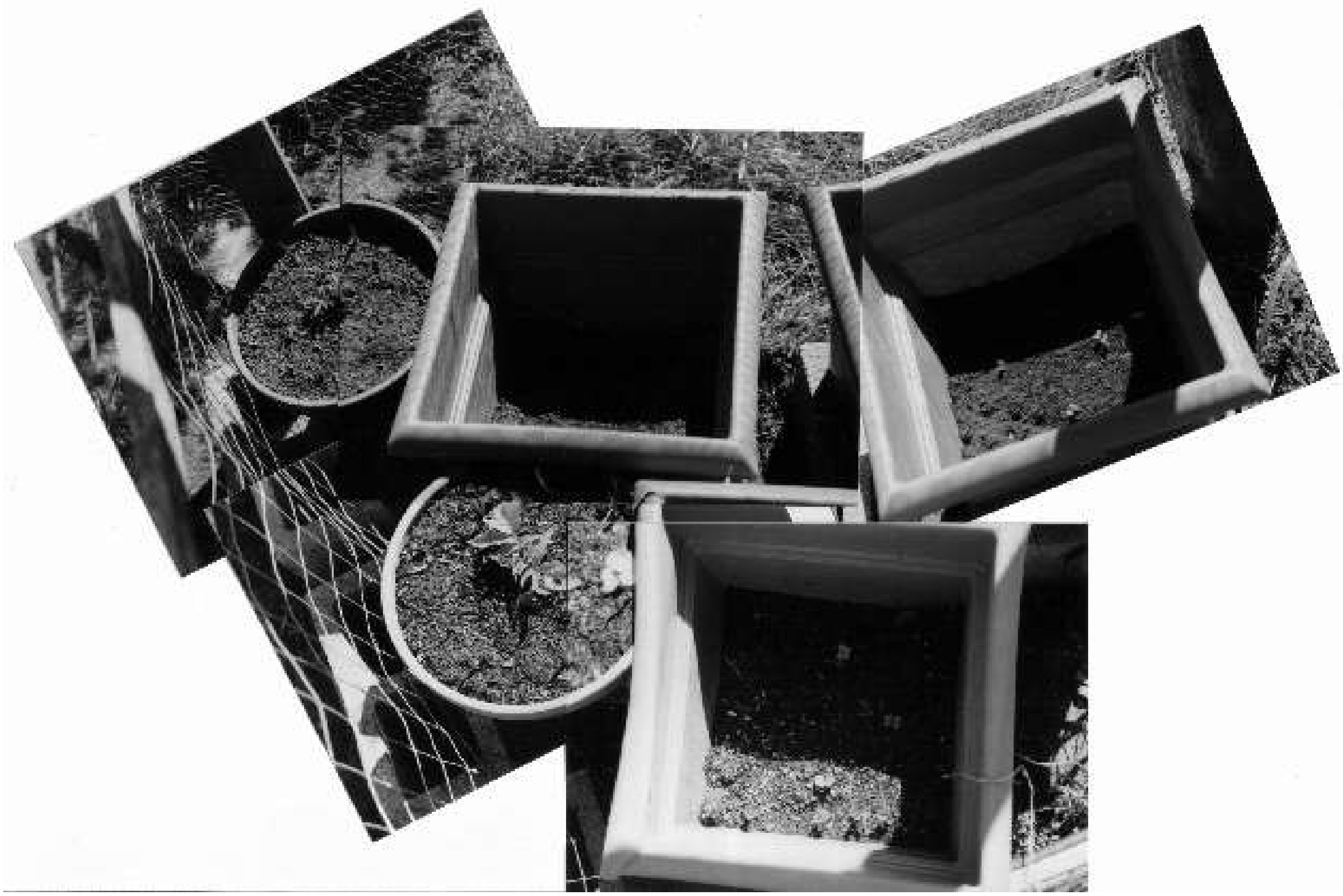
Now, I will return to my central hypothesis that rabbits can significantly aid in the development of fertile Martian soil. In March of this year, I began experimenting with growing food in 17 kg of Mars soil simulant JSC Mars-1 enhanced with rabbit feces. I have dubbed this experiment the Lagomorph Environmental Processing Utility Study, or LEPUS.

First of all, I would like to introduce the crew. My wife Gail and I have rescued over 200 abandoned rabbits since 1992, and have placed about 70% of them for adoption in permanent homes (for more information on Bunny Hill, please visit: http://members.xoom.com/mars_ultor/rabbits/html/rabbits.htm).

Madeline and Tiger are New Zealand Whites who were abandoned in San Francisco in 1998. A few days after they were rescued, Madeline gave birth to seven bunnies, but because they were transported to our house under conditions that allowed the babies to get too cold, five of them died the first night. Gail and I named the two surviving bunnies Scully and Mulder.

I have two sets of experiments running. The first set consists of three identical containers, each with a soil depth of 6 cm and surface dimensions of 33 x 33 cm. The planters contain: 1) commercially available potting soil, 2) unmodified

JSC Mars-1, and 3) rabbit-enhanced JSC Mars-1. Rabbit droppings are normally hard, encapsulated spheroids of fibrous material, which take some time to break down and mix with soil. I artificially accelerated this process by shredding the material in my kitchen blender . . . you might want to keep that in mind if you ever come over to my place for frozen margaritas. Well, as I said, rabbits present a near-zero health risk to humans. When I mixed the shredded rabbit feces with the JSC Mars-1, the change in the physical character of the soil was dramatic: rich, fluffy, aerated soil, as opposed to dense, fine sand. It certainly looked and felt like a good growth medium.



All three soils were exposed to rain over a three-week period prior to planting. The unmodified JSC Mars-1 packed down hard like beach sand in the tidal zone. The rabbit-enhanced JSC Mars-1, however, retained much of its aeration.

Planted in the first experimental set were:

- tomato
- radish
- carrot
- onion
- peas

It turns out that I grossly underestimated how much volume the rabbit feces added to the JSC Mars-1 (it was only 1,740 g, but bulky), so I had to remove approximately one-third of the rabbit-enhanced JSC Mars-1 to get back to the same volume as the other two samples. I used this surplus material to experiment with other vegetables, with potting soil as a control, but without pristine JSC Mars-1 for comparison. Planted in the second experimental set were a white potato and eight garlic cloves. The two containers in this set were ceramic bowls 33 cm in diameter by 12 cm deep.

I planted Sets 1 and 2 on 24 March 1999. The image shown above was recorded on 12 April. None of the vegetables that were planted from seed germinated well in any of the soils, but it should be noted that the weather was consistently cooler than normal due to La Niña conditions, and that the soils were in shadow for much of the daytime due to the height of the containers.

On 17 April I planted Roma tomato seedlings in Set 1. The next image was recorded on 24 June.

The superior performance of the rabbit-enhanced JSC Mars-1 can be seen clearly. The tomato plant in this soil is several times larger than the plants in the unmodified JSC Mars-1 and the potting soil. On this date, the first tomato fruit was observed in the rabbit-enhanced JSC Mars-1. The first fully developed pea pods were also harvested from rabbit-enhanced JSC Mars-1 on 24 June. The garlic plants in rabbit-enhanced JSC Mars-1 are noticeably larger than in potting soil. I didn't expect potatoes to flourish in such small containers, and indeed, after 42 days the plant in rabbit-enhanced JSC Mars-1 shows little growth, but the potato in potting soil died during this time. In all soils, some of the carrots I had planted on 24 March were just getting started. Again, this is a testament to the unusually cool spring.

In early July, sustained daytime temperatures in excess 40 degrees Celsius severely damaged the plants in the experiment; however, the tomato plants continued to produce. Of course, temperatures in this range would not be a concern on Mars.

The following table shows the results obtained so far:

Crop Yields as of 1 September 1999 (grams)

Crops	Potting Soil	Unmodified JSC Mars-1	Rabbit-enhanced JSC Mars-1
(Set 1)			
tomato	95	75	580
radish	none	none	none
carrot	none	none	none
onion	none	none	none
peas	10	5	10
(Set 2)			
garlic	40	N/A	80
potato	none	N/A	50

So far, it looks like rabbit stuff has the "right stuff."

Lessons Learned

The experiment containers were set up 25 cm above ground to isolate them from weeds and garden pests. This caused a problem with excessive drainage, so that it was difficult to keep the experiments properly hydrated during the hot summer weather. The experimental setup will need to be redesigned for 2000.

Also, in the case of the first experimental set, the depth of the containers, relative to the small amount of soil used, resulted in excessive shadowing which inhibited growth in the early stages. At the same time, one must bear in mind that crops on Mars will be exposed to much weaker sunlight than on Earth.

Finally, the dense packing of hydrated pristine JSC Mars-1 may inhibit root development. In follow-on experiments, the performance of pristine JSC Mars-1 should be compared with that of samples which include a non-nutrient amendment.

Future Plans

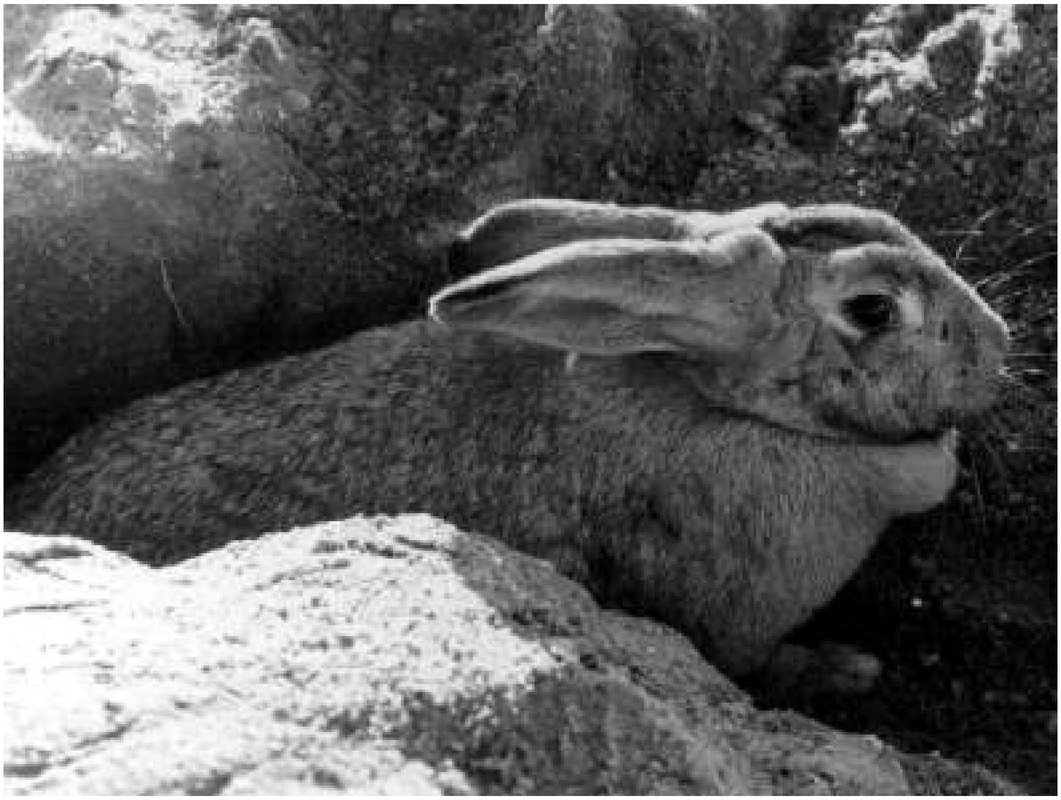
If the rabbit-enhanced JSC Mars-1 continues to show promise, humane experiments including rabbits themselves will be in order.

A rabbit population should be maintained in constant exposure to simulated Martian regolith to test for health effects. A follow-on phase of this experiment should incorporate results from the Mars Environmental Compatibility Assessment (MECA).

A space flight program should be developed to study the adaptability of the rabbit to the environmental conditions of various phases of a Mars mission, including powered flight, microgravity, and Mars gravity. At this time, I envision a shuttle-launched, shuttle-retrievable MarsRabSat that would either deploy or inflate to a large-diameter toroid and spin to simulate 0.38 g. In addition to video recording rabbit behavior under Mars gravity conditions, the long-term effect of 0.38 g on rabbit physiology could be studied upon retrieval. Such a mission would be a significant predictor of human physiological adaptability to Mars gravity, and could also serve as a precursor for a larger manned facility.

Possible Role of the Rabbit in Later Stages of Mars Colonization

It should be noted that rabbits burrow underground in the wild. On Mars, this behavior will reduce their exposure to two of the problematic conditions of the Martian environment: radiation and cold. Because of the rabbit's short period from conception to sexual maturity, the combination of selective breeding and genetic engineering should allow the rapid development of a breed that would be able to survive in successively low-pressure environments. This suggests the possibility of releasing a Mars-conditioned rabbit subspecies – *Oryctolagus cuniculus martianus* – into the wilds of Mars at an earlier stage of ecopoesis (terraforming) than other mammal species.



Someday, our descendants may go for a walk in a park, and see a red rabbit sitting under a redwood tree, on a planet that isn't so red anymore.

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