Responses of the cryptoendolithic Antarctic black fungus Cryomyces antarcticus in liquid media irradiated with space-relevant Fe ions

Claudia Pacelli*†[1,2], Mun Siong Loke , Alessia Cassaro[1], Ralf Moeller[3], Laura Selbmann[1,4], Laura Zucconi[5], Akira Fujimori , and Silvano Onofri[5]

[1]Dept of Ecological and Biological Sciences, University of Tuscia, Viterbo, Italy – Largo dell'Università s. n. c., Viterbo, Italy

[2]Italian Space Agency (ASI) – Via del Politecnico snc, Rome, Italy

[3]German Aerospace Center, Institute of Aerospace Medicine (DLR) – Cologne, Germany

[4]Italian National Antarctic Museum (MNA), Mycological Section – Genoa, Italy

[5]Dept of Ecological and Biological Sciences, University of Tuscia, Viterbo, Italy – Largo dell'Università snc 01100 Viterbo, Italy

Abstract

Outer space and surface of most celestial bodies are subjected to large fluxes of ionizing radiation, which constitute the major damaging factor in space. Galactic Cosmic Rays are high-energy charged particles originating outside the Earth's solar system. They consist of 98% nuclei and 2% electrons that markedly differ in their relative abundance; 85% of the nuclei component is represented by protons, 12% by a-particles and 1.5% by heavier nuclei (Ferrari and Szuszkiewicz, 2009). Although their relative abundance is comparatively low, Fe ions are the most significant component of Galactic Cosmic Rays in terms of energy deposition (Durante and Cucinotta, 2011; Edwards, 2011). They are harmful for any form of terrestrial life since they can interact either directly or indirectly with all relevant biomolecules, resulting in a combination of dense ionization along the trajectory of the particle, and secondary ionizations of various energies that can diffuse in multiple directions and to varying distances from the particle trajectory: this makes shielding from this kind of radiation quite challenging, and poses one of the principal unknowns in understanding its effects on any (terrestrial) organism.

Despite this recognizable role of radiation in life endurance, its effects on organisms are still not well characterized. The capability of the Antarctic cryptoendolithic black fungus *C. antarcticus* in resisting to space-relevant radiation has already been demonstrated. In desiccated conditions, the fungus was able to survive the radiation environment experimented in Low Earth Orbit, outside the International Space Station (Onofri et al., 2012, 2015, 2019), and high doses of ionizing radiation (up to 55 kGy, Pacelli et al., 2017).

Here, we investigated for the first time, the survival capability of this fungus to increasing doses of outer space–relevant Fe ions, in metabolically active conditions. In the frame of STARLIFE irradiation campaign (Moeller et al., 2017) colonies in liquid cultures were

*Speaker

†Corresponding author: claudia.pacelli@asi.it

irradiated with accelerated Fe ion (150 MeV/n, LET 2.2 keV/μm) doses (up to 2 kGy), at the HIMAC (Heavy Ion Medical Accelerator in Chiba) facility at the National Institute of Radiological Science (NIRS) in Chiba, Japan. Preliminary results showed that the fungus maintained high vitality (20% of survivors at 1 kGy) and metabolic activity; moreover, only minimal DNA damage was detectable by PCR approaches. These results have expanded our knowledge on the resistance of fungi and on the limits of extremophilic Earth-based microbial life, representing the only possible reference in the search of life beyond Earth. These data will also aid in assessing the risks of forward contamination when sending spacecraft to extraterrestrial planetary bodies.

References

Durante, M. and Cucinotta, F.A. (2011) Physical basis of radiation protection in space travel. Rev Mod Phys 83:1245–1281.

Edwards, A.A. (2011) RBE of radiations in space and the implications for space travel. Phys Med 17(S1):147–152.

Ferrari, F., and Szuszkiewicz, E. (2009) Cosmic rays: a review for astrobiologists. *Astrobiology*, *9*(4), 413-436.

Moeller, R., Raguse, M., Leuko, S., Berger, T., Hellweg, C. E., Fujimori, A., ... and STARLIFE Research Group. (2017). STARLIFE-An international campaign to study the role of galactic cosmic radiation in astrobiological model systems. Astrobiology, 17(2), 101-109.

Onofri, S., de la Torre, R., de Vera, J. P., Ott, S., Zucconi, L., Selbmann, L., ... and Horneck, G. (2012). Survival of rock-colonizing organisms after 1.5 years in outer space. Astrobiology, 12(5), 508-516.

Onofri, S., de Vera, J. P., Zucconi, L., Selbmann, L., Scalzi, G., Venkateswaran, K. J., ... and Horneck, G. (2015). Survival of Antarctic cryptoendolithic fungi in simulated martian conditions on board the International Space Station. Astrobiology, 15(12), 1052-1059.

Onofri, S., Selbmann, L., Pacelli, C., Zucconi, L., Rabbow, E., and de Vera, J. P. (2019). Survival, DNA, and Ultrastructural Integrity of a Cryptoendolithic Antarctic Fungus in Mars and Lunar Rock Analogs Exposed Outside the International Space Station. Astrobiology, 19(2), 170-182.

Pacelli, C., Selbmann, L., Zucconi, L., Raguse, M., Moeller, R., Shuryak, I., and Onofri, S. (2017). Survival, DNA integrity, and ultrastructural damage in Antarctic cryptoendolithic eukaryotic microorganisms exposed to ionizing radiation. Astrobiology, 17(2), 126-135.