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How can tardigrades survive in other moons like Enceladus?

P. G. Núñez[1], M. E. Peña-Salinas[1,2,3] and R. Vázquez[3]

[1] Instituto de Estudios Avanzados de Baja California, A. C., Calle Mármol 187, Fracc. Costa Azul, 22880 Ensenada, Mexico, e-mail: pgnunez@ideabc.org
[2] Facultad de Cs. Marinas, Universidad Autónoma de Baja California, Km 103 Carretera Tijuana-Ensenada, 22860 Ensenada, Mexico
[3] Instituto de Astronomía, Universidad Nacional Autónoma de México, Km 103 Carretera Tijuana-Ensenada, 22860 Ensenada, Mexico

Abstract. Tardigrades are considered one of the most extreme organisms on the planet. They have extreme survival ability, this is due to cryptobiosis, making them to survive in extreme conditions. In the recent years it has been said that life could emerge in Enceladus, Saturn's icy moon. One hypothesis is that these organisms could survive in Enceladus. On Earth, some inhabit the Arctic Ocean in cryoconite holes. The strategy to tolerate and/or survive these temperatures is accumulating sugars like trehalose and polyols. Could they survive on Enceladus? probably, but there is still some work to do on understanding the genes that trigger these protection strategies against the freezing temperatures.

Key words. Extremophiles: Tardigrades. — Cryptobiosis. — Astrobiology: Enceladus

1. Introduction

Tardigrades are microscopic organisms that have gained importance in Astrobiology in recent years, and today are considered one of the most extreme organisms on the planet. They are also denominated water bears, due to its general appearance and its slowness when moving (Miller 2011). These organisms have extreme survival ability, they can enter into a state of latency for several years called cryptobiosis and this mechanism can be of different types, anhydrobiosis (lack of water), anoxybiosis (lack of oxygen), osmobiosis (low pressure), and cryobiosis (freezing temperatures) (Nelson et al. 2010), making them to survive to different extreme changing conditions, even ionizing radiation.

In the recent years it has been said that life could emerge in Enceladus, Saturn's icy moon, this is because Cassini probe has confirmed the existence of a long-lived global ocean laced with organic compounds and biologically available nitrogen (Deamer & Damer 2017).

2. Strategy of survival

One of the hypotheses of this work is that these organisms survive to the extreme environmental conditions in Enceladus. We know that these organisms can live and survive in extreme conditions on Earth, some inhabit the Arctic Ocean like genera Halobiotus, Pseudechiniscus, and Styraconyx. Some were found recently in cryoconite holes which are

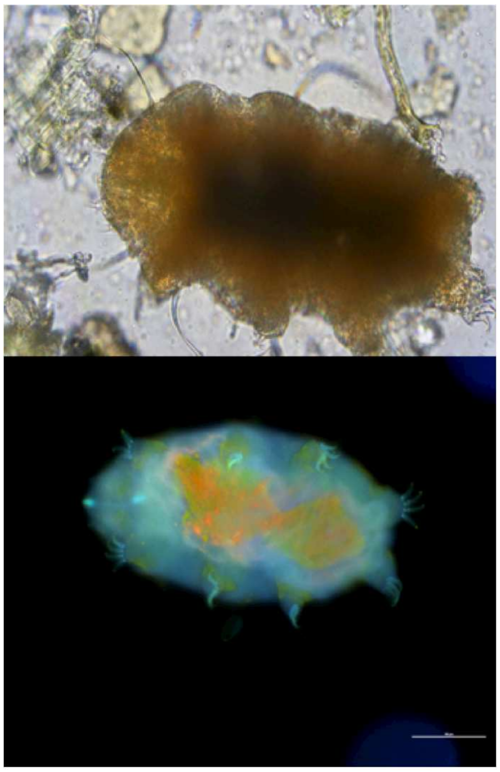

Fig. 1. *Echiniscus blumi* viewed in optical and fluorescence microscopy.

water-filled reservoirs on a glacier's surface (Zawierucha et al. 2016).

Some species like Hypsibius dujardini, Pilatobius recamieri, and the genera Ramazzottiidae, as well as other micro-invertebrates, were found in Antarctica (Tsujimoto et al. 2016). The strategy to tolerate and/or survive these temperatures is accumulating sugars like trehalose and polyols. This action protects membranes and proteins against phase transition and controls the ice fraction and minimum cell volume resulting from freeze concentration and osmotic dehydration

3. Conclusions

Tardigrades can survive in a diverse types of habitats, with a great variation of physical parameters, one of them is the survival in the coolest environments, like the tardigrade Acutuncus antarcticus, living in the Antarctica (−98.6ºC, Giovannini 2018). Other genera as Halobiotus, Pseudechiniscus, and Styraconyx, found in the arctic ocean and other in structures like the cryoconites (Hypsibius, Pilatobius, and Ramazzottidae), some like Echiniscus and others we found in high mountains like San Pedro Mártir, Mexico (−17ºC; see Fig 1.). Enceladus has a deep ocean whose water has a pH of 8.5 and earths is 8, and a temperature of a surface temperature of −198ºC. Could they survive on the moon Enceladus? Most likely they could survive, because a tardigrade has been able to survive in $T < -200$ºC, however, we are not sure if it could reproduce under these conditions. Still some work to do on understanding the genes that trigger these protection strategies against the freezing temperatures.

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