



Research Letter from a Swedish Lapland cabin

Water Bears in Space!

By our corresponding author, **Björn Rymdörare**

Hälsningar! Now, it is a little-known fact that when enduring our long, dark, cold winters, we Swedes tend to think about life's limits and how they might be expanded elsewhere. Previously, the Vikings went off to America and the Goths of Gotland went to Africa and Asia. More recently, Abba and IKEA have conquered the world but now Swedish water bears are all set to take on outer space!

Water bears are small, multicellular invertebrates that have been found in nearly all ecosystems from the Himalayas (above 6,000 m) to the depths of the oceans (below 4,000 m), and from polar regions to the equator. Named in 1773 for their eight-legged walk, which Johann Goeze found reminiscent of the loping gait of a bear, their formal taxonomic name, *Tardigrada*, means 'slow walker'. However, what sets Tardigrades apart is their amazing capacity to survive experimental abuse.

Ingemar Jönsson from the Aquatic Biology and Chemistry Group at Kristianstad University has spent years conceiving of ever more extreme ways of testing a water bear's hold on life, from total desiccation (you can remove 99% of their water and still revive them years later) to intense gamma irradiation (they can survive levels a thousand times higher than any other animal) but in his latest paper, "Tardigrades survive exposure to space in low Earth orbit" (*Current Biology* vol. 18, R 729-31), he's demonstrated Tardigrades' extra-terrestrial qualities.

In science fiction, *Star Trek* may have immortalised the phrase 'to boldly go where no man has gone before', but Jönsson has his own ideas on the matter. Consider the name of his pet project, the TARDIS – a reference to intergalactic science fiction? On his web site, it is an abbreviation of 'Tardigrades in Space', but who can fail to spot the homage to the unusual, time-travelling spacecraft used by Doctor Who (the BBC TV sci-fi institution)? However, unlike Dr Who, who is never confronted with the vast, empty wastes of outer space, Ingemar Jönsson has put his water bears to the test – and using elaborate machinery in the laboratory is no longer enough. This time there has been no simulation: outer space is outer space! One might wonder just what the chances are, in the normal course of events, that a water bear would encounter the deep vacuum and unfiltered cosmic radiation of outer space but Jönsson has insisted on exposing his victims to the real thing. There will be no further simulation!

Harsh punishments

With the kind assistance of the European Space Agency's FOTON-M3 mission, Jönsson has now successfully sent some 3,000 adult water bears from two species, *Richtersius coronifer* and *Milnesium tardigradum*, on a twelve-day space trip orbiting the earth at some 270km. Although they had time to go round 189 times, it is unlikely the water bears saw much of their trip

since they were in their desiccated dormant state at less than 0.01% of their normal metabolic activity. Which is just as well since for 10 whole days Jönsson exposed them all to the vacuum of outer space. Just to make things even tougher, two-thirds of his water bears were simultaneously roasted by UV radiation – half in the UV-A/UV-B range (280-400nm), and the remainder to the full UV range from vacuum-UV to UV-A (UV-ALL 116.5-400nm), which is "more than a thousand times stronger than on the earth's surface". Oh, and incidentally, "All samples were also exposed to ionizing solar and galactic cosmic radiation."

Well, after all this punishment, Ingemar Jönsson sounds almost genuinely surprised that there was anything left to revive upon their return to earth, but these Tardigrades are evidently tougher than the toughest! They all shrugged off 10 days of space vacuum, "with no significant difference in survival pattern compared to controls" (the controls wisely stayed on earth "under ambient laboratory conditions").

Vacuum plus UV radiation was somewhat tougher – *R. coronifer* died en masse but an incredible 68% of the *M. tardigradum* specimens exposed to UV-A/UV-B, "revived within 30 minutes" of rehydration, although "subsequent mortality was high". Even when exposed to UV-ALL, three individuals survived to tell their tales, or at least to lay eggs, with the eggs from the UV-A/UV-B survivors hatching as well as the controls.

As Jönsson casually remarks, "How these animals were capable of reviving their

body after receiving a dose of UV radiation of more than 7000 kJm⁻² under space vacuum conditions remains a mystery." In a spirit of true Scandinavian understatement, he then notes that "these results add the first animal to the exclusive and short list of organisms that have survived such exposure."

Hitchhiking around the galaxy?

Furthermore, other experimenters have made some equally astounding observations – water bears can survive being heated to 151°C for a few minutes, chilled for days at -200°C, and even a few minutes at -272°C (yes, <2°C above Absolute Zero). In addition to vacuum, they can withstand more than 1,200 times atmospheric pressure (nearly six times the pressure of water in the deepest ocean trench). They can also resist 570,000 rads of X-ray radiation (<2,000 rads would be fatal to a human).

As astrobiologist Gerda Horneck of the German Aerospace Centre says, this ability to survive in extreme conditions "might be important when we consider the habitability of other bodies in our solar system or beyond."

Or, as *The Economist* magazine put it, "More broadly, such hardiness leads to a question about whether tiny life forms may be able to hitchhike around the galaxy on meteorites – or even spacecraft. It is said that the meek will inherit the Earth. Perhaps the tardigrades will inherit the universe."

