Astrobiological Research on Tardigrades: Implications for Extraterrestrial Life Forms

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Possible Extraterrestrial Life Forms

Are we alone in the universe?

possible extraterrestrial life forms

unicellular organisms

multicellular organisms

neglected
Tardigrades

-well known examples of extremotolerant animals-

• Classification  - Phylum Tardigrada
  >1000 species

• Body length  - 0.05 ~ 1mm

• Habitats  - Various environments

• Characteristics  - Anhydrobiosis,
  Tolerance to extreme environments
Anhydrobiosis - an ametabolic dry state induced by desiccation

- dehydration
- anhydrobiosis
- rehydration

- 1~3% body water content
- ametabolic
Tolerance to extreme environments

- **High temperature**  
  +151°C  
  (Rahm, 1921)

- **Low temperature**  
  −273°C  
  (Becquerel, 1950)

- **High pressure**  
  7.5 GPa  
  (Ono et al., 2008)

- **Radiation**  
  - X-rays  
  10 kGy  
  (May et al., 1964)
  - γ-rays  
  7 kGy  
  (Jonsson et al., 2005)
  - Heavy ions  
  8 kGy  
  (Horikawa et al., 2006)
Tardigrades survived open space environments that have

- **Space vacuum**
- **Massive UV radiation** (7577 kJ/)

at low Earth orbit

*Milnesium tardigradum*

Jonsson *et al*. 2008
Model species: *Ramazzottius varieornatus*

We have established a culture system for a tardigrade species

*Ramazzottius varieornatus*

- Collected from mosses in Sapporo, Japan
- Algae as food
- Anhydrobiotic capacity through its whole life history

Model for astrobiological research

(Horikawa et al. 2008)
UV radiation tolerance

• Evaluation of UV radiation tolerance

• Mechanisms behind the tolerance
UV radiation tolerance

Procedure

Active

Anhydrobiosis

UV irradiation

Rehydration
UV radiation tolerance

Post-irradiation culture

- **Temperature:** 22°C
- **Food:** Green alga *Chlorococcum* sp.
- **Light conditions:** Continuous dark

![Diagram of agar plate with food](image)

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UV radiation tolerance

Survival ability

*R. varieornatus*

*R. varieornatus* (Anh.)

Survival ability

*R. varieornatus* (Anhydrobiosis) > *R. varieornatus* (Active)

(Horikawa et al. 2013)
UV radiation tolerance

Reproduction capacity

*R. varieornatus* (Anhydrobiosis) > *R. varieornatus* (Active)

(Horikawa et al. 2013)
UV radiation tolerance: DNA damage

- Anhydrobiosis has protective effects on DNA against UV radiation.
Mars Environmental Chamber Experiment

**Mars Environmental Chamber**
(41 days)

- Anhydrobiosis
- Regolith
- Filter paper

**Rehydration**

-80 to 25°C
- CO₂: 95%; O₂: 0.13%
- 10 mbar
- UV+ or UV–

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More than 70% of the animals survived after exposure to simulated Martian environments.

(Johnson et al. 2011)
The animals exposed produced new generation.

(Johnson et al. 2011)
Anhydrobiosis has protection effects on DNA against UV radiation.

Tardigrades could survive in Mars surface environments for 41 d if they are covered with thin layer of regolith.

There are possibilities that there are some multicellular-like organisms on the Mars-like environments.
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Thank you.