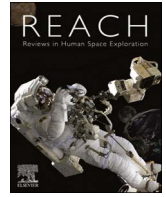




Contents lists available at ScienceDirect

REACH - Reviews in Human Space Exploration

journal homepage: www.elsevier.com/locate/reach

Planetary protection challenges in space exploration missions and ways of their resolution with account of Russian exobiology experiments



O.I. Orlov^a, N.D. Novikova^{a,*}, N.A. Polikarpov^a, M.A. Levinskikh^a, E.A. Deshevaya^a,
M. Sugimoto^b, V.R. Alekseev^c, T. Okuda^d, O.A. Gusev^{e,f}, V.N. Sychev^a

^a Institute of Biomedical Problems of Russian Academy of Sciences, (IBMP), Moscow, Russia

^b Institute of Plant Science and Resources, Okayama University, Okayama, Japan

^c Zoological Institute, of Russian Academy of Sciences, St.-Petersburg, Russia

^d National Institute of Agrobiological Sciences, Tsukuba, Japan

^e Institute of Fundamental Medicine and Biology, Kazan Federal University, Kazan, Russia

^f RIKEN, Yokohama, Japan

1. Introduction

In view of recent flights of space probes to other planets of the solar system, many space agencies have incorporated search for extra-terrestrial life or its predecessors into their research programs. However, deep space missions are fraught with high risks of disseminating terrestrial life forms, which may have unexpected consequences. Propagation of and contamination by Earth's life forms, mainly microorganisms with their unprecedented resistance to extreme environments, may exclude the possibility of exploring planets in their pristine conditions. Of greater concern is potential Earth's contamination by extraterrestrial organisms or by terrestrial pathogenic microorganisms that were transformed during their exposure to the space environment and brought back to Earth.

Understanding the necessity of investigating planets in their unaltered state led to the concept of planetary protection or planetary quarantine, which was put forth by an international nongovernmental organization, viz., the Committee on Space Research (COSPAR) established in 1958. The concept was first formulated at the COSPAR Assembly in 1964 [1], and the final version was adopted by the COSPAR Resolution of 2002 [2].

This document forms the basis of procedures aimed at protecting planets from contamination by terrestrial microorganisms as well as at protecting Earth from back contamination by returning vehicles. However, planetary protection cannot be achieved without a comprehensive study of microbial survival in open space. Relevant studies are important not only for natural sciences theories but also for the practical implementation of efficient planetary protection measures.

It can be assumed that the outer surfaces of robotic and piloted space vehicles are populated by millions of microbial cells, many of which are in spore forms known for their high resistance to harsh environments. With the purpose of studying microbial survival during long-term exposure to outer space, IBMP developed hard- and software

and ran a series of Biorisk experiments on the outer surface of the Russian segment (RS) of the International Space Station (ISS).

The goal of the experiments was to accumulate data about potential manifestations or limits of phenotypic adaptation and genotypic changes in bacterial-fungal associations regularly found on the spacecraft construction materials. The primary purpose of the first experiment in the series was to verify the viability of test cultures within microbial-construction material systems after a long-term (comparable to the duration of a Martian mission) exposure in open space. The secondary objective was to evaluate spaceflight effects on biospecimens under study.

As known, not only microbes but also some highly organized organisms have the ability to enter into a dormant phase under adverse environmental conditions [3,4]. It is no exaggeration to say that many living creatures may reach a state when their vital functions are temporarily stopped to survive unfavorable environmental effects, e.g., diapause or cryptobiosis. These states differ in mechanisms allowing various organisms to reach dormancy as well as in levels providing their survival. In diapause and cryptobiosis organisms can survive a wide range of extreme chemical and physical effects, [5,6], thus making possible the transfer of living matter across space.

In view of this, the second Biorisk experiment was performed to study survival limits of microorganisms as well as or more highly organized biospecimens, including dormant higher plants, insects and lower crustaceans, after their exposure for the time similar to the flight to Mars.

2. Equipment and methods

2.1. Equipment and methods in the first Biorisk experiment

The equipment of the Biorisk experiment (Fig. 1) consisted of three containers, each loaded with 24 plastic petri dishes of 65 mm in

* Corresponding author.

E-mail address: novikova@imbp.ru (N.D. Novikova).