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宇宙海洋と宇宙養殖の概念

Concept of Space Ocean and Aquaculture

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1. Introduction

In this paper, the concept of the space ocean and aquaculture[1)] is introduced and also the technological development and future prospects of space aquaculture that will contribute to the establishment of the space ocean, based on research conducted to date are explained.

2. Space Ocean

There is a core biome as a concept of an artificial environment that cuts out the global environment as a place where humans live outside of the earth. The hydrosphere in the core biome is called “the space ocean”. Seawater is filled in a large pool, and selected aquatic organisms such as fish, crustaceans, and seaweed are released into it to build an ecosystem, and it is planned to simulate the global environment by exchanging substances with the biome such as the land zone. As we look forward to long-term residence in space, the existence of oceans or water bodies is considered important as a food source, a means of avoiding cosmic radiations, and a place of relaxation.

However, in order to construct a space ocean based on the traditional idea of a core biome, which involves carving out the Earth's ocean and selecting and incorporating various aquatic organisms into one hydrosphere to maintain an existing ecosystem, it is necessary to use groups of organisms that are less likely to migrate or be predated, or envision expanding the vast ocean into space. In other words, if the space ocean is considered as a copy of the Earth's ocean, the maintenance and management of the ecosystem becomes a major issue.

3. Aquaculture in Space

For living on Mars or other planets, where it is difficult to smoothly supply resources due to the distance from the earth, a controlled ecosystem life support system CELSS that provides the place of human habitat and produces food with material recycling is necessary. Therefore, experimental studies with the aim of developing a higher-order food production technology of supplying animal protein by applying fish farming (Aquaculture) in space have been conducted. Aquaculture in space, it is conceived to produce individual organisms at a high density, divide each organism and accommodate into modules, and control the movement

of substances to maintain a constant biomass of each organism.

First, our studies were aimed at producing of the edible fish, tilapia *Oreochromis niloticus* from their waste by establishment artificial food chain. The assumed material flow from tilapia waste to their juveniles was analyzed using these experimental data. These results showed that 5.17% of nitrogen and 5.54% of phosphorus excreted from reared tilapia are accumulated in tilapia fry in one food chain cycle. In addition, aquaponics, which uses tilapia rearing water as liquid fertilizer for hydroponic cultivation of vegetables, has been studied for a long time, and the use of these complex food production technologies also will be able to enrich the food situation in space.

Next, experiments using aircraft on tilapia's swimming and feeding behavior under different gravity was conducted. From the results, it was also clarified that swimming and feeding are possible by irradiating visible light from one direction even under microgravity and it is possible to maintain their posture from about 0.1G, and under 0.2G under without lighting. These results suggest that tilapia show the normal swimming and is possible by fully adapting to the gravity of the moon and Mars (Figure 1).

In the future, it is necessary to study aquaculture technology with a view to alternation of generations, assuming long-term fish breeding.

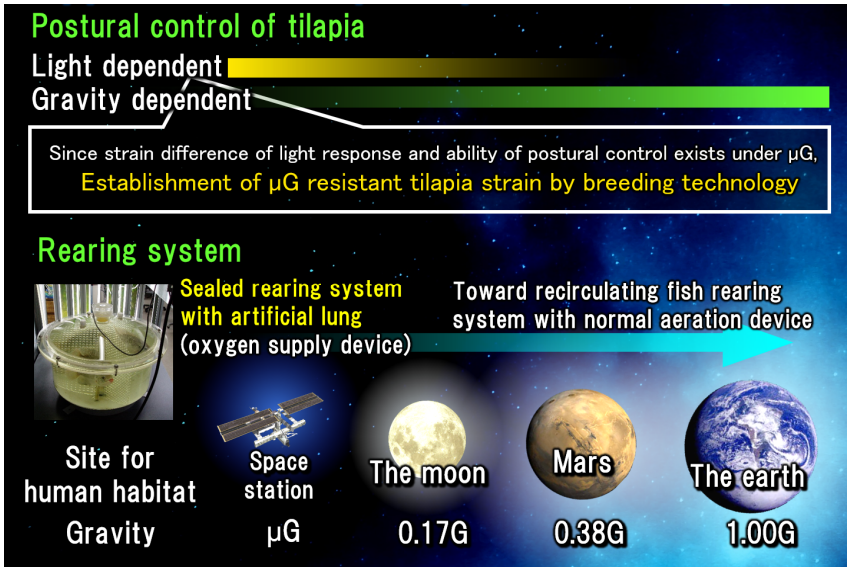

Figure 1. Application of tilapia aquaculture in space

4. Conclusions

For establish a space ocean that simulates the Earth's ocean, it must be large enough to maintain a minimum number of organisms at low densities for food chains and generational changes under low nutrient conditions. The challenge is to maintain this ongoing ecosystem without causing it to collapse. The elemental technology of space aquaculture that can reduce this scale and control material circulation in the food chain of the ecosystem will contribute to the realization of not only material recycling-type seafood production in space in the future, but also the space ocean. It is believed that this will greatly contribute to solving the various issues required for its establishment.

References

1) M. Endo, R. Masuda and Y. Yamashiki: Space ocean and aquaculture. In Human Spaceology - Three Core Concepts for Space Migration , Kyoto University Press (2023).