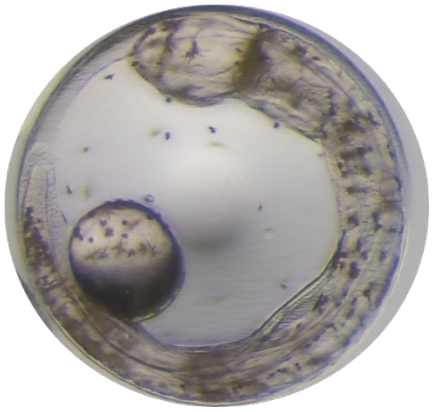
Fish on the menu at the future moon base?



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After the first tomatoes, salads and potatoes have been grown in space, will astronauts soon raise fish aboard the ISS or on the Moon? That is the challenge of the Lunar Hatch mission carried out by IFREMER. Objective: to fertilize fish eggs and hatch them to feed the astronauts who will reside on the future ESA (European Space Agency) moon base. A new study published in the journal *Frontiers in Space Technology,* in partnership with the University of Lorraine, confirms that sea bass eggs resist weightlessness very well, an essential quality to consider for their space travel.

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Since its launch in 2019, the Lunar Hatch program has made significant progress. Several hundred sea bass eggs produced in aquaculture underwent a battery of tests and demonstrated their ability to withstand the conditions of rocket takeoff and space travel.

> "We tested the effects of several factors likely to disrupt embryonic development or the viability of sea bass eggs. The sea bass is a model fish at IFREMER, the aquaculture of which we have mastered, but also one of the candidate species to travel to the Moon," explains **Cyrille Przybyla, researcher in marine biology, IFREMER**. "We know how to program the hatching date of their eggs based on the water temperature: the eggs take around a hundred hours to develop at 14°C and double that at 10°C. This time

> frame coincides perfectly with the duration of a trip to the Moon, i.e. between 4 to 8 days."

After subjecting these eggs to the vibrations of a Soyuz rocket launch and the associated sound environment, they were subjected to hypergravity, that is to say to an acceleration of the rocket from 1g to 5g. Project scientists observed that survival and hatching rates were identical to control eggs virtually remaining on Earth.

100 WEIGHTLESS BASS EGGS

The next step consisted of testing the effects of simulated microgravity, in other words weightlessness (or the absence of gravity) for 39 hours, a duration equivalent to 26 revolutions in low orbit around the Earth in the ISS. Scientists carried out this experiment on the University of Lorraine's ESA-accredited experimental platform, with the support of French National Centre for Space Studies (CNES).

> "Here again, the proportion of eggs that hatched is the same as the control eggs that remained in Earth's gravity. All in good health, they hatched 6 hours before the others, reports Cyrille Przybyla. We do not yet know precisely why, but this phenomenon of advanced hatching has already been observed in fish during a change in environment such as environmental acidification or even during a past experiment in a space station".

Beyond the eggs quality, the IFREMER scientists showed that young larvae aged 4 hours have the same behavior as their terrestrial counterparts.

The team is currently evaluating the influence of cosmic radiation on embryos during the journey. By leaving the Earth's magnetosphere and atmosphere, they will indeed be strongly exposed to a mixture of charged particles. To assess the possible impacts of this radiation, scientists are working in collaboration with the Institute for Radiological Protection and Nuclear Safety (IRSN), and exposing hundreds of fertilized sea bass eggs to proton and neutron fluxes in the MIRCOM and AMANDE irradiation facilities. The results are being analyzed and will be published in 2024.

WILL REALITY CATCH UP WITH FICTION?

The next step will consist of sending several capsules filled with fish eggs into low orbit to study their behavior in real situations. Scientists will then be able to conclude on the feasibility of sending them to the Moon to feed, in addition to fruit and vegetable production in greenhouses, a crew of 7 future residents. The idea is to offer fish on the menu twice a week and to provide a supply of fish eggs approximately every 6 months. As for the water used to raise the fish, it will be recycled in closed circuits in aquaculture systems inspired by those developed at IFREMER, so as not to lose a single drop!

Embryogenesis of an aquaculture fish (Dicentrarchus labrax) under simulated altered gravity, Cyrille Pryzbyla *et al.*, *Frontiers in space Technology (2023)* doi: 10.3389/frspt.2023.1240251

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