Bacteria could make salmon healthier

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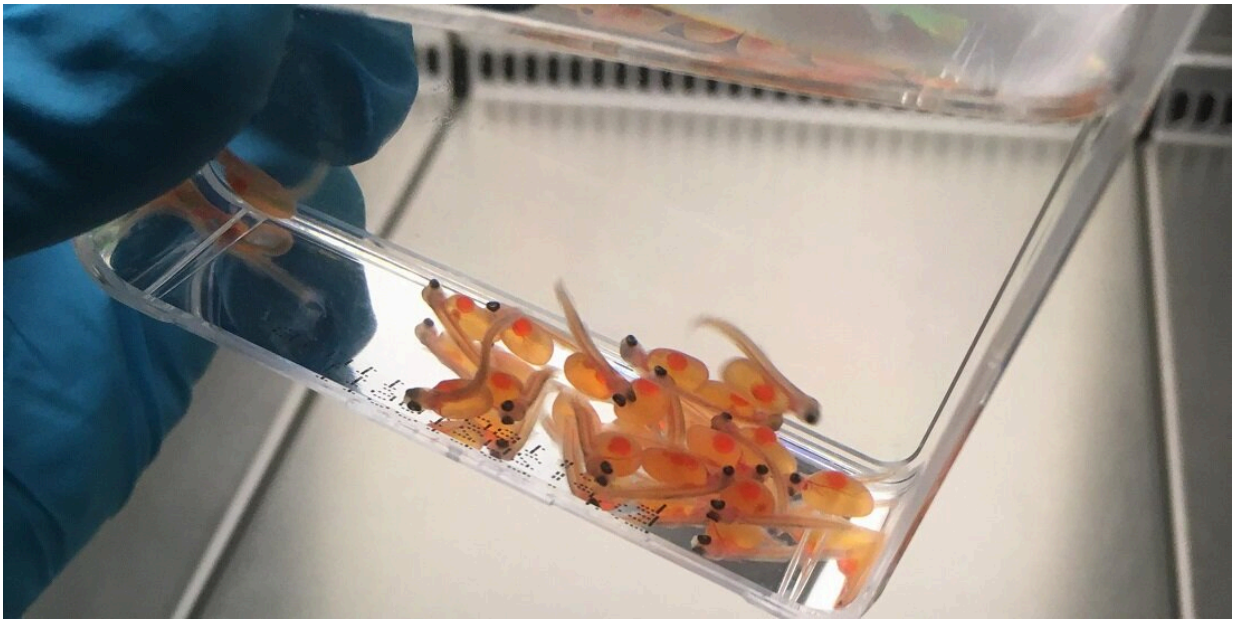

Researchers at NTNU have successfully kept salmon fry bacteria free for up to 12 weeks after the eggs have hatched, facilitating experiments that might one day make the fish healthier. Credit: Alexander Fiedler, NTNU

Researchers, including from NTNU, are breeding bacteria-free fish fry. This pursuit is more important than you might think.

"We're managing to keep the fry bacteria-free for up to 12 weeks after the eggs hatch," says Ingrid Bakke. She is a professor at NTNU's Department of Biotechnology and Food Science.

This step has now helped researchers on the trail to figuring out how bacteria and fish affect each other. Understanding their interaction could one day also lead to a method for preventing the fish from becoming ill and, although still a long way off, could be good news for the fishing industry, our future food supply—and not least for the fish themselves.

The researchers have studied how bacteria affect the growth, genes and mucous membranes of the fish.

But first a little about the bacteria in your body.

Trillions of bacteria

Bacteria obviously affect our health, but not only in a negative way.

As long as we are inside our mother's womb, we live protected and perhaps even germ-free, but that ends as soon as we are born. A human body normally contains many trillions of bacteria—that's a number followed by 15 zeros. The same applies to other living organisms.

"Many of our bacteria are necessary for the human body to function. They're necessary for the development of our immune system, and they contribute to digestion and increase the energy value of the food we eat. They protect against disease bacteria and produce vitamins that we need," says Bakke.

All these functions and more help us to understand the importance of finding out more about how our bacterial friends work.

So how do researchers go about doing this research?

Gnotobiotic model systems

Model systems based on bacteria-free animals are also called "gnotobiotic experimental systems" and refer to systems where researchers can control which bacteria are present.

By comparing bacteria-free animals with "normal" animals colonized by bacteria, researchers can determine how bacteria affect the host's development and health.

For example, experiments with bacteria-free zebrafish and mice showed that some of the responses in the host to bacterial colonization are the same in fish and mammals. Several of these bacteria involve the development of the immune and digestive system.

Knowledge from model systems

"A lot of what we know about how bacteria affect the host organism comes from experiments with model systems," says Bakke.

What does that actually mean?

Model systems are living organisms that are easy to work with when studying biological processes. Most often, these species are easy to breed, cheap to maintain, have a reasonably long life cycle and have genetic traits that are easy to manipulate and other favorable features.

The specific characteristics researchers look for mostly depend on what they want to study. Zebrafish, banana flies and different kinds of mice and rats are among the most well-known species used as model systems.

Bakke and her colleagues have chosen a different species this time: Atlantic salmon.

Bacteria-free salmon fry

Salmon fry go through a stage where they live with a pouch called a yolk sac. This yolk sac supplies nutrition for the fry.

"We've come up with a model system where we can keep the yolk sac of the salmon fry bacteria free throughout the 12-week yolk sac phase," says Bakke.

Fish are normally bacteria-free in the egg phase, but are colonized by bacteria as soon as they hatch. In contrast to all other salmon, these bred fry have no natural bacterial community.

The researchers breed the fish in a protected, germ-free environment, a standard method for making bacteria-free salmon fry. The research group has come up with an efficient and effective method that works for salmon eggs and fry.

"We surface treat the fish eggs to keep them bacteria free and keep the eggs, and later the fry, in bacteria-free water," says Bakke.

Knowing how to create bacteria-free fry is necessary for the group to research them afterwards.

Salmon are like blank slates

The bacteria-free fry become almost like a kind of blank slate where the researchers can add the bacteria they want and then see exactly what happens, without interference from unknown bacteria.

"Bacteria-free model systems are generally important for understanding interactions between the bacteria and host," says Bakke. "An example

would be understanding how gut microbiota affect development and health in humans and other mammals."

The microbiota consist of all the microorganisms found in our whole body or parts of our body.

"We can use bacteria and bacterial communities that we define, and investigate how both the host and bacteria are affected by living together," says Bakke.

For example, the researchers can investigate which factors control the composition of bacterial flora in the fry. The researchers may then be able to influence the bacterial composition in the fish to avoid negative effects, or they can introduce good effects instead.

Salmon fry well suited for research

Zebrafish have been widely used as a model system in this context. But salmon fry have some characteristics that make them particularly suitable.

"We have large and well-developed fry, which makes them easier to study," says Bakke.

The fry phase is long enough for the researchers to carry out several types of experiments. Since the fry obtain their nutrition from the yolk sac, the researchers don't need to add fish feed that could contain microorganisms that disturb the research results. As a bonus, the fry are nice to look at.

Bacteria found to affect skin mucus layer in salmon

To date, the researchers have published one article about their findings, but there are more to come. In the first article, they show that bacteria affect the protective skin mucus layer in the fish.

"The salmon have a protective mucus layer on the surface of their body. It appears that the composition of bacteria might affect the properties of this mucus layer," says Bakke.

The fry that were not exposed to bacteria developed a thinner mucus layer on the outside of their bodies than the fry that were exposed to the researchers' specially selected bacteria, or bacteria from a lake.

The bacteria can also affect the fat reserves of the fish. The fry that received bacteria from a lake developed greater fat reserves.

"We needed interdisciplinary expertise to study the effect of bacteria on the fish's mucus layer. Researcher Sol Gómez de la Torre Canny was key in developing the germ-free model system with yolk sac fry," says Bakke.

Researcher Catherine Taylor Nordgård, who is an expert in rheology, characterized the properties of the mucus layer that covers the fish.

Opens the door to treat fish

The goal of the researchers is to understand which mechanisms affect the composition of the bacterial communities that colonize the fish immediately after hatching.

"We're looking at how the bacterial communities possibly protect against bacterial infections, and whether it's possible to influence the early bacterial colonization of fry," Bakke says.

Enabling such probiotic treatment would mean that researchers could add live microorganisms to the fish to achieve beneficial effects, such as better health and growth.

"But probiotic treatment on a large scale is still a long way off," says Bakke.

The Norwegian product Stembiont is already available. This is a probiotic product intended for larger fish.

The work is published in the journal *Frontiers in Cellular and Infection Microbiology*.

More information: Sol Gómez de la Torre Canny et al, A novel gnotobiotic experimental system for Atlantic salmon (Salmo salar L.) reveals a microbial influence on mucosal barrier function and adipose tissue accumulation during the yolk sac stage, *Frontiers in Cellular and Infection Microbiology* (2023). DOI: 10.3389/fcimb.2022.1068302

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