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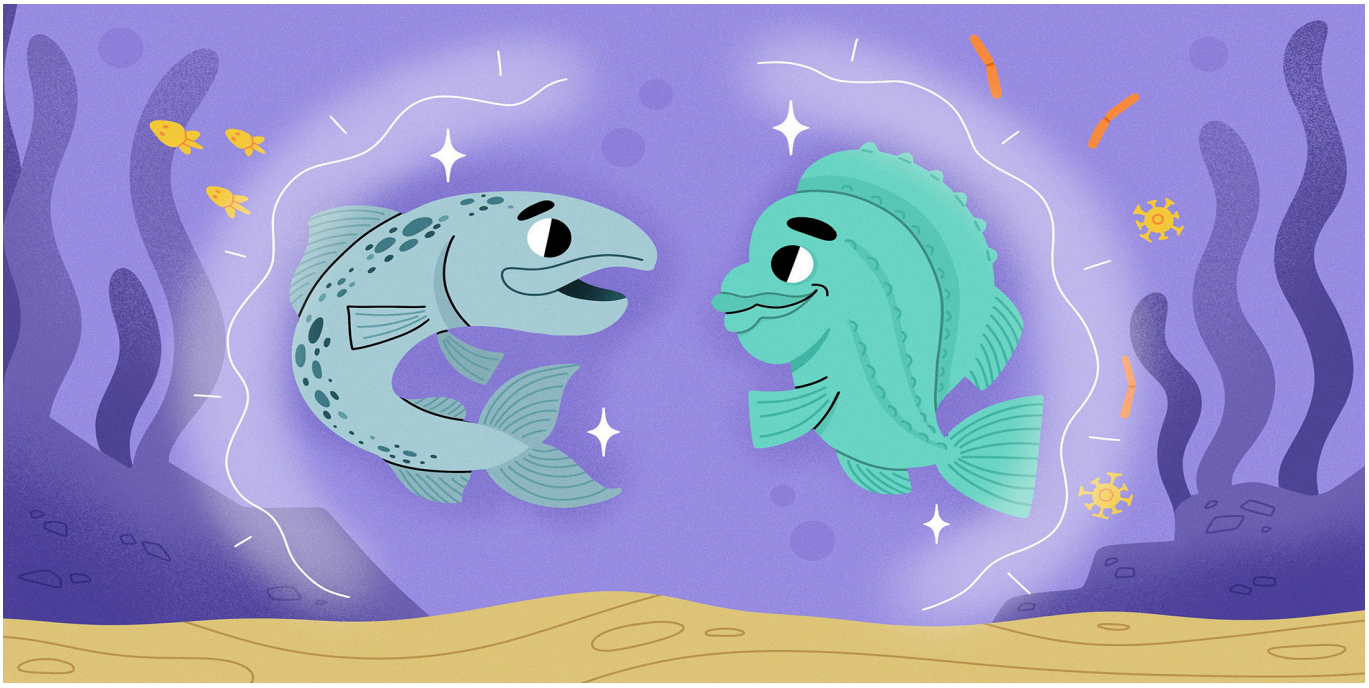

HOW DO LUMPFISH PROTECT THEMSELVES AGAINST VIRUSES?

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YOUNG REVIEWERS:

EDNA
AGE: 10

LORENZO
AGE: 13

For many people, a delicious salmon dish satisfies their taste buds. Salmon farming is a big industry, providing food for millions of people every day. However, the journey of this delicious meal from the ocean to your plate depends on lumpfish, a cool-looking fish that protects farmed salmon by eating sea lice. Sea lice are small parasites known to attack salmon and can cause disease if not removed. Since lumpfish are vulnerable to diseases, it is crucial to understand more about this organism's complex immune system, as this will help keep them healthy so they can then do their important "job" of eating sea lice. In this article, we will explain how we study the way the fascinating lumpfish defends itself against diseases.

WHAT ARE LUMPFISH?

Exploring the tremendous diversity of life under the sea is always exciting. Many children dream of what it would be like to be a fish swimming in a deep ocean, immersed in the same water where many extraordinary creatures live. Lumpfish are some of the cutest and

SEA LICE

A small ocean parasite that infects salmon and other similar fish, feeding on their skin and blood. They can kill the fish if not treated.

PARASITES

An organism that lives on or in a host and gets its food from or at the expense of its host.

Figure 1

(A) Imaginary illustration of lumpfish guarding farmed salmon. Credits: Bing/DALL-E. **(B)** Image of a lumpfish. **(C)** Image of lumpfish feeding on sea lice attached to a farmed salmon. Image credits: AquaDocs.

MICROBES

Organisms that are too small to be seen without a microscope, such as bacteria and viruses.

VIRUSES

Small pathogens that can infect any living organism and make it weak and sick.

TRANSCRIPTOMICS

Methodology used by scientists to understand how genes function and how they regulate various processes in the cells, tissues, and organs.

GENES

The fundamental unit of genetic information passed from parents to offspring. Genes contain the information needed to specify physical and biological characteristics and keep an organism functioning correctly.

strangest-looking fish. Imagine a fish covered in spots that look similar to bubble wrap and with a sticky belly. That is the cute lumpfish. Upon first glance, they may look like something straight out of a cartoon (Figures 1A, B), but lumpfish are actually underwater heroes that protect salmon from a pest called **sea lice**. Salmon are important for humans because they are eaten by people from all over the world (Figure 1C). Sea lice are small **parasites** that attach to the body of salmon, which may die if sea lice are not removed [1–3]. Sea lice are a problem for both wild and farmed salmon.

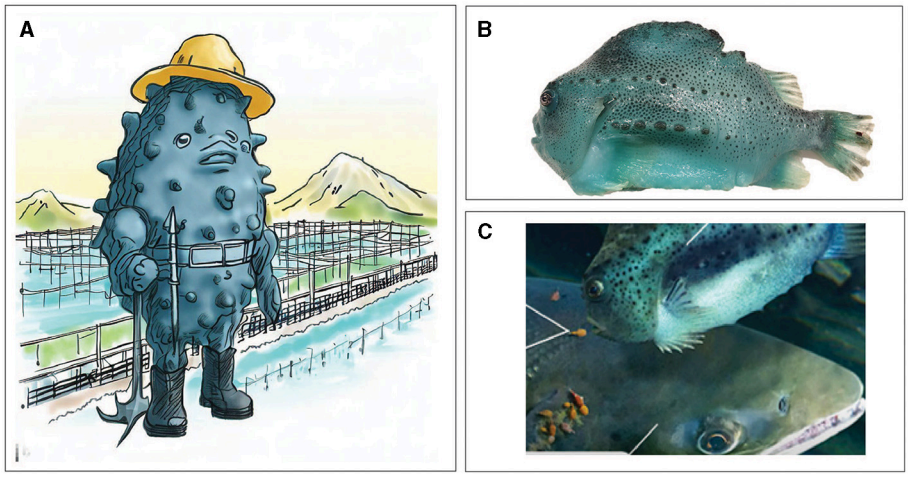

Figure 1

Salmon cannot remove the sea lice attached to their bodies. So, lumpfish and other cleaner fish act as guardians of farmed salmon, ensuring that salmon remain healthy. However, lumpfish themselves can fall sick due to certain diseases [4]. Scientists are here to save both lumpfish and salmon by understanding their fight against diseases. Scientists have tried to understand how lumpfish defend themselves against disease-causing **microbes**, and if not, why? Scientists can then use this information to develop vaccines that protect lumpfish against diseases. As a first step toward creating vaccines against **viruses** that can kill lumpfish, scientists examined how lumpfish typically defend themselves against viruses.

WHAT IS TRANSCRIPTOMICS?

Scientists can use a methodology called **transcriptomics** to understand how specific immune **genes** function and how these genes respond when lumpfish encounter viruses. Genes are like the body's instruction manual. They instruct cells on how to grow and which function to perform [5]. The body usually only activates those genes needed for specific tasks. Otherwise, the body would waste a lot of energy. For example, genes that help to defend against infections are only "turned on" when a dangerous microbe is detected. Transcriptomics allows

scientists to determine which genes are being used by a cell at any given time (Figure 2).

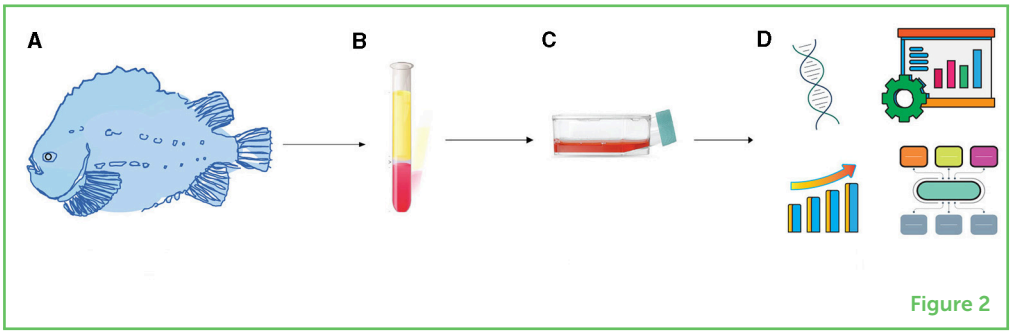

Figure 2

Schematic diagram of the experimental protocol. Immune cells are isolated from lumpfish, treated with reagents to mimic immune responses against viruses, and analyzed. **(A)** Lumpfish. **(B)** Immune cell collection. **(C)** Mixed with viral mimic. **(D)** Analysis.

Imagine the body as a big city with many buildings, each with a specific function. Each building contains people who oversee various tasks, like police, doctors, firefighters, teachers, and bankers. Similarly, the body is made up of multiple cell types, each with its own set of jobs. To fully understand what each worker is doing within a building, we must watch them closely. For instance, when there is a fire hazard in the city, the firefighters, police, and doctors are called upon, and the whole traffic will make way for their immediate actions. With proper communication between these services, the consequences of the fire hazard can be reduced to a minimum. Like firefighters are "activated" when there is a fire hazard, specific **immune system** cells are activated when there is an infection, the functions of the body's cells result from interactions between active genes. The scientific methodology to know which genes are active and inactive is called transcriptomics. Transcriptomic analysis tells scientists which set of instructions genes were given to a specific cell or tissue at a specific moment. These instructions are called **transcripts**. Thus, scientists can use transcriptomics to learn about an organism's responses to infections and how immune system cells communicate with one another. This knowledge helps scientists develop vaccines to prevent diseases, including vaccines to help lumpfish be prepared to fight infections.

IMMUNE SYSTEM

The body's defense system that protects it against hazardous bacteria and viruses. The immune system contains unique cells, tissues, and organs.

TRANSCRIPT

The complete set of information available in a particular cell coded by a gene that was activated by an external factor.

WHAT HAPPENS WHEN IMMUNE CELLS ARE EXPOSED TO VIRUSES?

To understand how the immune system of lumpfish works, scientists examined how the cells of the immune system responded to a chemical that tricks the fish into thinking a virus is present in its body (Figure 2). By carefully observing the cells of the lumpfish immune system and using transcriptomics to know which genes were activated, scientists got a complete picture of all the processes and genes activated by the virus-mimicking chemical. As many as 1,872 genes were activated after only 1 day! This result shows that lumpfish are well-prepared to defend themselves against viruses.

Scientists also noticed that several essential genes were very active in the immune systems of lumpfish, namely those genes containing instructions to produce proteins that can sense viruses and genes involved in communication between immune system cells. When the powers of the immune system's cells combine, they form a formidable barrier against infections, helping lumpfish stay healthy.

LUMPFISH: THE HEROES OF SALMON FARMS

Lumpfish are the often-overlooked champions of salmon farming that heroically protect salmon against sea lice, ensuring that this essential food resource remains available for the world's growing population. So, we must keep lumpfish healthy so they can continue to protect the salmon that humans love to eat. Scientists want to continue helping fish farmers control the spread of diseases in the places where salmon is raised, and one day you can also help us keep the fantastic lumpfish healthy and strong.

ORIGINAL SOURCE ARTICLE

Rao, S., Lunde, H. S., Dolan, D. W. P., Fond, A. K. S., Petersen, K., and Haugland, G. T. 2023. Transcriptome-wide analyses of early immune responses in lumpfish leukocytes upon stimulation with poly(I:C). *Front. Immunol.* 14:1198211. doi: 10.3389/fimmu.2023.1198211

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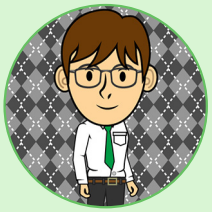
CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

EDNA, AGE: 10

Edna is a bright and curious 10-year-old. Her curiosity drives her to explore the wonders of nature, and she constantly brainstorms about ways to make the world a better place. Edna is also passionate about helping others. Her sociable nature brings joy to everyone she encounters. In addition to her passion for baking, she also plays piano and enjoys gymnastics.



LORENZO, AGE: 13

Hey there! I am a curious Italian boy interested in science and politics. I love learning and staying in nature, and I hope to be a good Young Reviewer! 😊

AUTHORS

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