FindingPheno

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Fish are also farm animals

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When you speak with someone about farm-grown meat, perhaps the first thoughts are chicken, beef or pork. But fish can also be grown on farms via aquaculture. Aquaculture farms can take many forms, from big tanks on land to nets or pens in the water, and can include fresh or salt water depending on the farmed species. Fast advances in aquaculture technology in recent decades have increased the numbers and diversity of farmed marine species, and today aquaculture accounts for half of all seafood consumed globally. This growth is expected to continue (predicted CAGR of 5.8% for the next 5 years) largely due to increasing consumer preference for farmed seafood, viewed by many as a healthy and sustainable diet option.

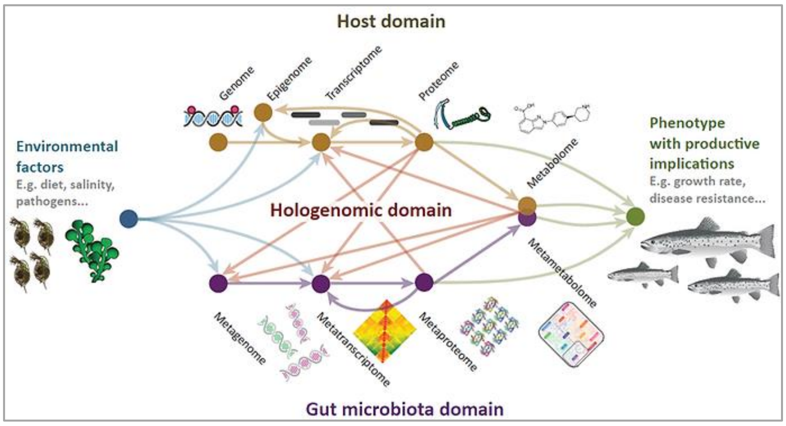
Fish can be green

Eating fish grown on a farm does not contribute to the ongoing decline of wild populations. Some breeding systems used in farms can help to restock depleted fish species in the wild. Aquaculture has lower carbon emissions than for example, beef production producing ten times more CO_2 than salmon farming. This is in large part because fish are very efficient in turning inputs like protein in their feed into meat compared to warm-blooded farm animals. For example, salmon has a feed conversion ratio (FCR) of 1.2, *i.e.* they require 1.2 kg of feed to create a 1 kg increase in body weight. On the other hand, beef cows have FCRs of 6-10. Moreover, by-products from aquaculture production can be repurposed to other uses ("circular economy") further reducing the environmental footprint. For example, leftover fish skin that would otherwise be discarded can be used as ingredients in pet food or to create biogas for local buses.

Aquaculture has challenges

Despite these benefits, aquaculture is a relatively new industry with challenges, the biggest of which comes from the nature of aquaculture farms where many similar animals are grown close together (high-density monoculture). For e.g., fish in open pens lack solid barriers to the surrounding water. So faeces, uneaten food, and chemicals can wash out of pens, polluting the environment with excess nutrients. While this can be avoided with closed or recirculating systems, it is not possible for all fish species. One method for reducing these problems in open systems is integrated multi-trophic aquaculture (IMTA), where other species grow in close proximity to reduce waste. For e.g., seaweed or shellfish grown next to the fish pens to filter excess nutrients, converting it to biomass, then using the seaweed or shellfish as ingredients in fish feed, thus recycling nutrients while reducing external pollution. However, IMTA systems are complex and the methods are still under development.

Another big problem is the spread of disease among fish in close proximity to each other. These diseases can be caused by pathogenic bacteria (e.g. furunculosis caused by *Aeromonas salmonicida*), highly infectious viruses (e.g. Infectious Pancreatic Necrosis Virus or Infectious Salmon Anemia Virus), or parasites like sea lice (*Lepeophtheirus salmonis*). Disease outbreaks cause major economic losses for aquaculture farmers, with industry-wide estimates as high as $6bn lost per year. Also, disease may spread beyond the farm to local wild fish populations causing biosecurity hazards. Treatment methods have traditionally focused on antibiotics or harsh chemicals that may stress the fish, induce antimicrobial resistance, and contaminate the environment. This has led to strategies that reduce or prevent the spread of infection.



Microbiome can help

A key strategy to reduce disease is to support the health and natural resistance of fish with good farming practices. Fish have built in defense systems, including innate, adaptive immune responses and physiological features like changes in skin thickness, mucus secretion or nutrient availability that make it more hostile towards parasites or pathogens. The gut and skin microbiomes play a role in supporting these defense systems, *e.g.* helping shape immune development or affecting skin mucus production to fight infection. However, these microbiomes are negatively affected by factors like stress, poor nutrition, antibiotics, or infection that may reduce resistance to disease. In cases of sea lice infestations, microbes living on the lice can also damage fish health, for e.g., bringing pathogens that infect and weaken the fish making them more susceptible to lice infestation. Together these factors highlight the importance of understanding all parts of host-microbiome-pathogen/parasite systems when designing improved farming methods to reduce disease burden.

Another widely used method to reduce infection is fish vaccines. While most approved vaccines involve injecting fish individually, several oral vaccines are under development or in use where the antigen is introduced to the water (often as part of the food) then eaten by the fish and absorbed via the gut to stimulate the desired immune protection. The effectiveness of oral vaccines are influenced by several factors including vaccine formulation, host immune system, and the gut microbiome. Different gut microbes can either stimulate or suppress the tolerance mechanisms that work to reduce immune stimulation to microbial antigens. Therefore, by changing the composition of the microbiome in the right way, it may be possible to induce a better and more specific immune response to an oral vaccine.

So the next time someone mentions farming, think of fish! This is a rapidly growing area with challenges to solve, but also a lot of potential - especially when we fully unlock the power of host-microbiome interactions in these farm animals.

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