

Genetic Precision in Water: Advancing Aquaculture through Genomic Selection

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DESCRIPTION

Aquaculture has grown into a major contributor to global food supply, requiring continuous improvement in productivity, efficiency, and resilience. By analysing genetic markers spread across the genome, researchers and producers can identify individuals with desirable traits at an early stage, improving breeding outcomes with greater accuracy than traditional selection methods.

Unlike conventional breeding, which relies heavily on observable traits and pedigree records, genomic selection evaluates thousands of genetic variations simultaneously. These variations, often in the form of single nucleotide polymorphisms, provide a detailed genetic profile that reflects the potential performance of an organism. This allows breeders to select fish or shellfish with favourable characteristics such as faster growth, better feed efficiency, and increased resistance to diseases even before these traits are visibly expressed.

The application of genomic selection in aquaculture began gaining traction with advances in sequencing technologies and computational tools. As the cost of genotyping decreased, it became feasible to analyse large populations, making this approach accessible for commercial use. Species such as Atlantic salmon, tilapia, shrimp, and carp have been among the primary beneficiaries, with breeding programs integrating genomic data to enhance stock quality and consistency.

One of the major advantages of genomic selection lies in its ability to improve traits that are difficult or expensive to measure directly. Disease resistance is a clear example. Challenging fish with pathogens to assess resistance can be risky and resource-intensive. Genomic prediction allows breeders to estimate resistance levels without exposing entire populations to harmful agents. This contributes to healthier aquaculture systems and reduces dependence on chemical treatments.

Growth rate is another trait significantly influenced by genomic selection. By identifying genetic markers associated with faster

growth, producers can shorten production cycles and increase yield. This not only improves economic returns but also supports efficient resource utilization. Feed conversion efficiency, which determines how effectively fish convert feed into body mass, can also be enhanced through this approach, reducing feed costs and environmental impact.

Reproductive traits benefit as well. Fertility, egg quality, and larval survival are essential for maintaining stable production. Genomic data enables the selection of brood stock with higher reproductive performance, ensuring consistent output across generations. This level of precision in breeding decisions contributes to long-term sustainability in aquaculture operations.

Despite its advantages, genomic selection also presents certain challenges. The initial setup requires investment in infrastructure, including genotyping facilities and data analysis systems. Skilled personnel are needed to interpret results and manage breeding programs effectively. Additionally, maintaining genetic diversity is essential to avoid inbreeding, which can lead to reduced fitness and increased susceptibility to disease. Balanced breeding strategies are therefore required to combine genetic improvement with population health.

Environmental interactions play a significant role in the expression of genetic traits. Fish raised in different conditions may perform differently even if they share similar genetic profiles. This highlights the importance of considering environmental variables when applying genomic selection. Research continues to explore how gene-environment interactions influence outcomes, aiming to refine prediction models for various farming conditions.

The role of genomic selection extends beyond productivity. It contributes to sustainability by supporting the development of strains that require fewer inputs and have lower environmental impact. Improved disease resistance reduces the need for antibiotics, while better feed efficiency minimizes waste output. These benefits align with global efforts to promote responsible aquaculture practices.

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CONCLUSION

Genomic selection represents a significant advancement in aquaculture science, offering a powerful tool for improving the genetic quality of farmed aquatic species. By leveraging detailed genetic information, it enhances productivity, supports

sustainability, and contributes to the resilience of aquaculture systems. Continued research and collaboration will play an important role in refining this approach and ensuring its effective implementation across diverse species and environments.