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Commentary

Genomic Selection Models and Sustainable Aquaculture: Addressing Thermal Stress, Genetic Improvement and Environmental Challenges

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DESCRIPTION

Aquaculture and aquatic ecosystems are facing significant problems due to global warming, which puts crustacean production at risk from high heat events and rising temperatures. Because they are ectotherms with a limited ability to regulate their body temperature, crustaceans are susceptible to long-term heat stress. Nevertheless, they demonstrate exceptional thermal flexibility and behavioral thermoregulation in a variety of thermal zones.

Aquaculture is now the most efficient method of producing animal protein worldwide, accounting for nearly half of all fish and shellfish. Approximately one-third of the premium animal protein consumed worldwide comes from it as well. The main cause of this growth is advancements in breeding methods, which are crucial for improving stock genetics and, consequently, aquaculture output.

Moreover, various elements like agricultural practices, feed advancements, disease control and policy backing are crucial for the industry's sustainable growth. Breeding innovations are crucial because they directly affect the genetic quality of farmed species, which consequently enhances the industry's efficiency and growth.

In contrast to land-based livestock and crops, aquaculture breeding faces distinct challenges that significantly impact the development and implementation of genomic selection methods. Initially, the high reproductive capacity and external fertilization observed in numerous aquatic species lead to intricate family structures with large full- and half-sibling groups, making pedigree construction more challenging and increasing the significance of accurate within-family selection.

Secondly, several essential characteristics in aquaculture, including disease resistance, body weight, deformities and sex determination, demonstrate pronounced sex-linked inheritance patterns or necessitate destructive sampling, rendering large-scale phenotyping costly or unfeasible. Third, the aquatic setting presents considerable levels of genotype-by-environment interaction because of variability in water temperature, salinity, oxygen concentrations and farming methods, all of which can greatly influence prediction precision and model applicability across different farms or areas.

These traits require customized data gathering, model choice and cross-environment validation methods specifically designed for the realities of aquaculture breeding.

It also offers a summary of well-known computational tools for applying these models and evaluates the genomic prediction precision of various models across multiple species, delivering practical advice on choosing models based on their assumptions, advantages and appropriate use situations. The article addresses difficulties encountered by Genomic Selection (GS) models and examines their future potential in aquaculture breeding.

Fish serves as an important source of numerous essential micronutrients and plays a crucial role in the daily diets of billions of people globally. In the United Arab Emirates (UAE), the average fish intake per person is twenty-two kilograms, while aquaculture provides only two percent of the overall yearly fish consumption. This has resulted in a growing need to set up large aquaculture facilities in the UAE's coastal waters, primarily aimed at combating the shortage of fish supply. Significantly, the progress of extensive aquaculture farms in the UAE's open waters corresponds with the country's National food security strategy and substantial funds are being allocated for the development of aquaculture projects and associated infrastructure.

Marine aquaculture is crucial for addressing the increasing need for quality protein and maintaining ocean ecosystems, but it also presents challenges related to fish net safety and fish development. Aquaculture refers to the farming of fish within extensive underwater cages or nets situated in oceanic areas. Nevertheless, the netting utilized in these facilities serves as an essential element that can be easily harmed and hard to identify.

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These underwater structures are vulnerable to different types of harm and adverse environmental effects; powerful currents, severe weather conditions and natural predators can threaten the stability of fish cages, resulting in breaches or potential total collapse. In marine ecosystems, various organisms such as bacteria, algae and hydroids cling to the enclosures, a process known as bio-fouling, which harms both the fish and the structural strength of the enclosures.

These occurrences can lead to fish escapes, disturbing local ecosystems and possibly bringing in non-native species. Additionally, concentrated waste and leftover feed in the cages can lead to water contamination, impacting the adjacent aquatic ecosystem. To guarantee sustainable aquaculture methods, it's crucial to effectively oversee and reduce these possible harms, employing technologies and approaches that emphasize both fish welfare and conservation.

CONCLUSION

The incorporation of GS models in aquaculture breeding signifies a revolutionary method that offers significant potential for improving breeding efficiency and precision. The ongoing development of GS models, propelled by progress in genomics and artificial intelligence, provides unparalleled chances for precision breeding.

Even with the considerable advancements achieved, present GS models continue to encounter difficulties like enhancing prediction accuracy, boosting computational efficiency and successfully integrating intricate genetic effects. Conventional selective breeding depends on documented trait values and genetic connections determined by pedigree analysis.