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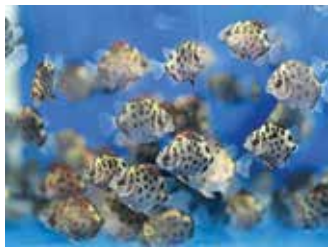
FISH TECH DIGEST

An E-Fisheries Science Quarterly Magazine





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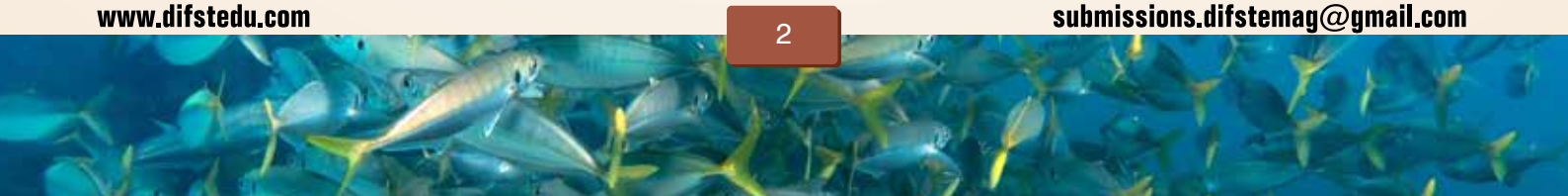
Editor,
Fish Tech Digest



Foreword

It is with immense joy and gratitude to God that I extend my heartfelt greetings to all readers of Fish Tech Digest, a quarterly e-magazine by the St. Devasahayam Institute of Fisheries Science and Technology (DIFST). This magazine is a testament to the innovative spirit and our advancing knowledge and promoting sustainability in fisheries and aquaculture.

The fisheries sector is pivotal in ensuring global food security, enhancing livelihoods, and promoting sustainable aquatic ecosystems. As Chairman of DIFST, I am deeply proud of this initiative, which seeks to bridge the gap between scientific research and practical applications. Fish Tech Digest stands as a platform for sharing insights, innovations, and best practices that will empower students, researchers, fishers and industry professionals alike. This magazine will serve as a beacon of ideas, sharing cutting-edge research, technological advancements, and success stories that can inspire transformative growth in this vital sector.

I commend the editorial team, under the leadership of Prof. S. Felix, for their dedication and effort in crafting a magazine that reflects our mission and vision. Their work exemplifies the spirit of collaboration and academic excellence that defines our institution. I am confident that it will inspire, educate, and serve as a catalyst for growth in fisheries science and technology.

As we launch this magazine, I encourage readers to actively engage with its content, provide feedback, and contribute to its growth. Let us work together to create a sustainable future for the fisheries sector, ensuring that our actions today have a positive impact on generations to come.

May this publication continue to flourish, enlightening minds and fostering sustainable development in this vital field.

Blessings and best wishes,
Most Rev. (Dr.).Nazarene Soosai Th. D.D.D.
Chairman, DIFST
Bishop of R.C. Diocese of Kottar

From the Desk of the Dean

Dear Readers,

Greetings from the DIFST!

In today's rapidly advancing world, the role of technology in agriculture and fisheries has never been more crucial. To ensure that innovations reach their fullest potential, it is imperative for educational institutions, particularly state agricultural universities (SAUs), to actively focus on bridging the gap between laboratory research and real-world application. The dissemination of new knowledge, techniques, and technology must extend beyond academic circles and into the hands of the communities who can truly benefit from them.

*Recognizing this, St. Devasahayam Institute of Fisheries Science and Technology (***DIFST***) is proud to introduce an initiative dedicated to knowledge-sharing and community empowerment: "***Fish Tech Digest"***—an e-magazine focused exclusively on the latest advancement in fisheries science and technology. This digital platform will showcase articles that cover a broad spectrum of topics, including aquaculture, aquatic environment, aquatic animal health, fish processing, fisheries engineering, fisheries economics, fisheries extension and fishing technology, presenting both research-backed insights and practical applications. Each issue will be carefully curated with high-quality articles supported by reliable national and international data, making Fish Tech Digest a trusted source of knowledge in the field.*

Moreover, this e-magazine aims to highlight collaborative efforts within the fisheries sector, drawing contributions from esteemed research institutions, other universities and KVKs (Krishi Vigyan Kendras). We hope to provide a space where the best ideas and practices in fisheries can be shared, with a strong focus on making a positive impact on farming and fishing communities across the state and the nation. Our commitment to this goal is unwavering, as we believe that true progress comes from collective growth and the continuous exchange of knowledge.

Fish Tech Digest is more than just a publication—it is our commitment to serving the community and advancing the field of fisheries science. I look forward to seeing the impactful insights and valuable contributions that will shape each issue, and I am excited for all of you to be a part of this journey.

Thank you for your continued support and engagement.

Warm regards,
S. Felix
Dean, DIFST

CONTENT

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Revolutionizing Aquaculture: The Power of Genomics in Shaping the Future of Fish Farming

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Abstract

Aquaculture has emerged as a vital contributor to global food security, surpassing capture fisheries in aquatic animal production. It plays a pivotal role in meeting the rising demand for high-quality protein, essential nutrients, and omega-3 fatty acids. However, the industry faces significant challenges, including climate change, disease outbreaks, and genetic resource depletion. Genomics offers transformative solutions by unlocking the genetic potential of fish to improve growth, disease resistance, reproduction, and sustainability. From decoding the genetic basis of traits like growth and scale development to enhancing disease resistance and understanding sex determination, genomics has revolutionized aquaculture practices. By leveraging these advancements, the sector can ensure sustainable growth and strengthen its role in addressing global hunger and malnutrition.

Introduction

In 2022, aquaculture made history by overtaking capture fisheries as the largest producer of aquatic animals, contributing 94.4 million tonnes—over half of the global output. This remarkable growth showcases aquaculture's potential to meet the rising demand for nutritious aquatic foods while tackling food insecurity and malnutrition. Aquatic foods now provide 15% of global animal protein and essential omega-3 fatty acids, vitamins, and minerals, making them critical for healthy diets worldwide (FAO, 2022). Despite this progress, aquaculture faces serious challenges, such as overfishing, climate change, germplasm loss, and diseases. Meeting the growing global demand—projected to increase by 22% by 2050—requires innovative solutions. Genomics offers a breakthrough, enabling scientists to decode the genetic secrets of fish to improve growth, disease resistance, and sustainability. With over 200 fish genomes sequenced, this cutting-edge science is driving a transformation in how we farm and protect aquatic resources.

Genomic applications in aquaculture

Genomics plays a crucial role in identifying the genetic factors linked to key aquaculture traits and detecting genetic variations influenced by environmental changes. This has numerous applications in fisheries and aquaculture, such as precise identification of fish stocks for effective capture fisheries management, conservation of fish genetic resources, and the use of genomic selection for genetic improvement. Genomic tools, such as DNA sequencing and marker-assisted selection, can help aquaculture producers make more informed breeding decisions and accelerate the genetic

improvement of their stocks. Overall, genomic applications in aquaculture have the potential to enhance sustainability, efficiency, and profitability in the aquaculture industry.Additionally, genomics aids in enhancing disease resistance, as well as sex determination and control. The following paragraph discusses some of the key applications of genomics in aquaculture.

Analysis of genetic resources

Genomics is revolutionizing the way we understand and improve aquaculture. By identifying key genes linked to important traits, genomics helps scientists study how fish adapt to their environments and how we can breed them for better productivity. For example, the genome of the common carp, one of the most popular fish in aquaculture, offers valuable insights into the genetic foundations of traits like colour patterns and size, helping to improve breeding techniques for the industry. In addition to aquaculture, genomics also helps us understand the incredible diversity of natural species. For instance, in the case of adaptive radiations, genomic research reveals the molecular processes that drive the wide variety of physical traits in species. This includes gene duplications, changes in non-coding regions of the DNA, and accelerated evolution, all of which contribute to the survival of species in different environments.

Moreover, genomics helps us understand how species adapt to environmental changes. In the case of species like the European seabass, genomics has shown how gene family expansions allow these fish to thrive in varying salinity levels (Tine *et al.*, 2014). Studies also show how natural processes like recombination and gene mixing shape genetic differences within populations, such as those between Atlantic and Mediterranean seabass. These insights are fascinating and essential for conservation efforts, helping to manage and protect species crucial to ecosystems and economies (Luand Luo, 2021).

Insights into disease resistance

Disease control is one of the biggest challenges in aquaculture, and understanding the immune systems of fish through genomic analysis is key to developing effective vaccines and treatments. Genomic applications also play a crucial role in disease management in aquaculture. By analyzing the genomes of various species, scientists can identify important genes involved in immune responses, helping fish resist diseases. Producers can selectively breed individuals that are more resilient to common pathogens and diseases by identifying genetic markers associated with disease resistance. This can help reduce the reliance on antibiotics and other chemical treatments, leading to healthier and more sustainable aquaculture practices.

For example, the Atlantic cod genome revealed a unique immune system, with an expanded set of MHC I genes and specialized Toll-like receptors that help the fish fight off pathogens. Similarly, the turbot genome revealed some missing immune genes, such as TLR4, showing that fish species vary in their immune systems (Houston *et al.*, 2008). In Atlantic salmon, researchers identified a genetic marker related to infectious pancreatic necrosis, which has helped improve

disease resistance in farms. In economically important species like the large yellow croaker found in China, studies showed that genes related to innate immunity are rapidly evolving, giving these fish a strong defence system against pathogens (Wu *et al.*, 2014). These genetic insights are crucial for better disease control and management in the aquaculture industry, improving the health and sustainability of farmed fish.

Genetic determinants of growth and development

Growth and development in fish are influenced by complex genetic, environmental, and physiological factors, making them a challenge to control in aquaculture. For example, in *turbot*, researchers have mapped growth-associated genetic markers to the fish's genome, helping to identify key genes that could enhance growth in farmed fish. Some of these genes, which have been used in livestock breeding, are linked to a major growth-related trait found in turbot, offering new ways to improve aquaculture practices. In species like *common carp*, genome sequencing has provided insights into how genetic variations affect physical traits like scale development. For instance, deletions in a specific gene led to a reduced-scale phenotype in carp, while other genes involved in pigment production influence the fish's coloration, showing how genetic factors shape appearance and growth (Xu*et al.*, 2014).

Comparative genomic studies between scaled and scaleless fish, such as *channel catfish*, revealed important genetic differences that explain the loss of scales in some species. This research underscores the importance of gene analysis for understanding structural traits and evolutionary changes in fish. In *grass carp*, which is crucial to global aquaculture, genome sequencing highlighted the absence of genes needed for cellulose digestion. However, studies found that during the transition from a carnivorous to herbivorous diet, certain genes related to circadian rhythms and liver metabolism were activated, which supports the fish's rapid growth when consuming plant-based foods. These findings are valuable for improving the genetic traits of herbivorous fish in aquaculture.

In flatfish, such as the *tongue sole* and *Japanese flounder*, the process of metamorphosis—where the fish's body changes from symmetric to asymmetric—was studied through genome and transcriptomic analyses. Scientists discovered that thyroid hormones, retinoic acid, and other signalling pathways play a crucial role in this transformation. This research sheds light on how flatfish develop and offers insights into the genetic mechanisms behind body shape changes in aquatic species.These genomic advancements provide crucial tools for enhancing growth, improving disease resistance, and understanding the genetic basis of important traits in aquaculture, paving the way for more efficient and sustainable fish farming (Luand Luo, 2021).

Genetic basis of sex determination

Biological sex in fish is a complex trait influenced by genetic, environmental, and social factors, making sex determination an important aspect of fish breeding. Understanding and controlling

sex is vital for improving reproductive efficiency, growth, and product quality in aquaculture. Genomic tools like whole-genome sequencing and transcriptome analysis have identified key sex-determining genes across various fish species. For example, in *turbot*, females grow faster than males, and genomic studies have pinpointed sex-related genes for marker-assisted selection to enhance growth. In *Asian seabass*, which transforms from male to female during maturation, gene duplications linked to gonad development play a crucial role in this transformation (Vij *et al.*, 2016). Similarly, in *salmonids*, the master sex-determining gene (*sdy*) blocks female differentiation, leading to male development, and its manipulation can reverse the process.

In *Atlantic cod*, multiple genomic regions related to sex determination were identified, revealing the evolutionary flexibility in the genetic architecture of teleost sex determination. *Tongue sole* has unique sex chromosomes derived from ancestral vertebrate chromosomes, and the gene dmrt1 on the Z chromosome has a role in male determination, similar to its function in birds. For tilapia, which is one of the most widely farmed fish, controlling sexual differentiation is crucial for maximizing growth. Male tilapias reach market size faster than females, making all-male populations preferable in aquaculture. Genomic studies of Nile tilapia have identified sex-determining regions on specific chromosomes, highlighting the importance of high-quality genome assemblies in understanding sex determination for aquaculture improvements (Conte *et al.*, 2017).

Conclusion

Genomics has proven to be a game-changer for aquaculture, offering innovative solutions to long-standing challenges in the industry. Its applications vary from improving growth and disease resistance to enabling selective breeding and sex control, are shaping the future of fish farming. As the global demand for aquatic foods continues to rise, integrating genomic tools into aquaculture practices is not just an opportunity but a necessity for sustainable development. By harnessing the power of genomics, we can ensure aquaculture remains a cornerstone of global food security, delivering nutritious and sustainable aquatic foods for generations to come.

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