OPEN ACCESS Freely available online

ISSN: 2155-9546
Journal of Aquaculture Research & Development

Commentary

Cellular Dynamics of Muscle Growth and Fiber Recruitment in Aquaculture Species

Tone-Kari Joost*

Department of Aquaculture and Aquatic Sciences, University of Tasmania, Hobart, Australia

DESCRIPTION

The addition of new muscle cells through precursor cell proliferation known as myocyte hyperplasia plays a vital role in the body growth, feed conversion efficiency, and overall yield of cultured fish. Unlike terrestrial mammals, which possess a limited window for muscle fiber proliferation, many fish species retain the capacity to recruit new muscle fibers well into adult life. This persistent hyperplastic growth allows skeletal muscle to continuously adjust to developmental stage, environmental parameters, nutritional inputs, and genetic traits over extended rearing periods.

Fish skeletal tissue consists primarily of white fast-twitch fibers, red slow, twitch fibers, and intermediate muscle fibers. White muscle provides high-intensity, short-duration burst swimming, whereas red muscle powers sustained aerobic movement. The proportion and structural layout of these fiber types vary widely among species, dictated by life stage, body size, ambient temperature, oxygen availability, and swimming behaviour. Early developmental stages are characterized by rapid fiber recruitment through myocyte hyperplasia. As fish mature, overall tissue expansion occurs through a combination of hyperplasia and hypertrophy, which is the enlargement of pre-existing muscle fibers.

The formation of new muscle fibers depends on myogenic precursor cells, particularly satellite cells, which remain responsive to developmental cues and external stimuli throughout life. Once activated, these precursor cells proliferate, differentiate, and fuse to construct new functional fibers or assist in tissue repair. The rate of cellular proliferation and differentiation fluctuates based on species, age, thermal exposure, exercise regimen, and nutritional status, with juvenile fish demonstrating significantly higher rates of precursor cell division than mature individuals.

Dietary nutrition serves as a primary driver of muscle tissue synthesis. Balanced protein intake supplies essential amino acids such as lysine, methionine, and leucine which act as critical building blocks for contractile structures, structural enzymes, and cellular proteins. In juvenile fish, where structural growth requirements are highest, high-quality feed supports rapid cell division and protein deposition. Conversely, extended periods of nutrient deprivation suppress precursor cell proliferation, while an excess of dietary energy lacking adequate protein disrupts optimal nutrient partitioning between metabolic maintenance and muscle development.

A complex network of molecular factors regulates myocyte proliferation and maturation. Myogenic regulatory factors, such as myogenic differentiation protein one and myogenic, dictate key stages of muscle cell commitment and differentiation myogenic differentiation protein one signals early myogenic lineage commitment, whereas myogenic drives cell fusion and functional fiber maturation. Additionally, endocrine pathways involving insulin-like growth factors, the mechanistic target of rapamycin, and key growth-related transcription factors coordinate cellular protein synthesis based on available nutrient signals and developmental stage.

Environmental parameters and husbandry conditions also heavily govern the extent of hyperplastic growth. As ectotherms, fish experience metabolic and enzymatic changes directly linked to water temperature. Within ideal physiological ranges, warmer conditions accelerate cellular proliferation and growth rates; however, thermal stress outside preferred limits dampens appetite and impairs muscle development. Similarly, physical exercise induced by water movement imposes mechanical demands that alter mitochondrial activity, fiber diameter, and precursor cell activation. Suboptimal water quality parameters-such as low dissolved oxygen, elevated ammonia or nitrite concentrations, extreme pH, or fluctuating salinity-trigger physiological stress responses that divert metabolic energy away from tissue production toward homeostatic maintenance, indirectly inhibiting muscle growth.

Myocyte hyperplasia directly impacts final product quality and consumer acceptance. The ratio of fiber number to fiber diameter influences fillet firmness, structural integrity, and

Correspondence to: Tone-Kari Joost, Department of Aquaculture and Aquatic Sciences, University of Tasmania, Hobart, Australia, E-mail: tonekari.joost@utas.edu.au

Received: 17-Aug-2026, Manuscript No. JARD-26-32976; **Editor assigned:** 20-Aug-2026, PreQC No. JARD-26-32976 (PQ); **Reviewed:** 03-Sep-2026, QC No. JARD-26-32976; **Revised:** 10-Sep-2026, Manuscript No. JARD-26-32976 (R); **Published:** 17-Sep-2026, DOI: 10.35248/2155-9546.26.17.1148

Citation: Joost TK (2026). Cellular Dynamics of Muscle Growth and Fiber Recruitment in Aquaculture Species. J Aquac Res Dev. 17.1148.

Copyright: © 2026 Joost TK. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

textural properties, alongside connective tissue architecture and lipid deposition. In modern aquaculture research, integrating histological measurements with molecular toolsets enables researchers to evaluate genetic lines, refine nutritional formulations, and optimize management practices for superior growth and flesh quality.

Furthermore, functional ingredients like specific polyunsaturated fatty acids, nucleosides, and immunostimulants can modulate localized inflammatory responses and systemic endocrine signals, thereby enhancing satellite cell viability, promoting protein retention, and supporting sustained hyperplastic recruitment in high-density aquaculture systems.

CONCLUSION

Beyond macronutrients like proteins and lipids, functional feed additives and micronutrients play a nuanced role in modulating muscle cell dynamics. Looking forward, the strategic integration of cellular muscle dynamics into selective breeding and technology opens new frontiers for sustainable aquaculture expansion. Breeding selection programs now incorporate markers tied to myogenic regulatory pathways alongside traditional growth metrics, allowing breeders to select for strains that exhibit both high hyperplastic potential and superior fillet texture. Trace minerals such as zinc, selenium, and copper serve as vital cofactors for antioxidant enzymes that protect rapidly dividing myogenic cells from oxidative damage during intensive growth phases.