

## EXAMINATION OF THE PHYSIOLOGICAL AND BIOCHEMICAL CHANGES AFFECTING NUTRITIONAL REQUIREMENTS THAT OCCUR IN DIFFERENT LIFE STAGES OF FISH

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**Abstract:** *Fish undergo many physiological and biochemical changes throughout life, each demanding distinct nutritional consideration. This study explores the nuanced relationship between physiological and biochemical changes influencing nutritional requirements in different life stages of fish. The research involved an ethical and comprehensive investigation into various fish species' embryonic, larval, juvenile, and adult phases. Results demonstrated significant variations in growth rates, emphasizing rapid larval growth and unique reproductive hormone patterns during adulthood. Enzymatic activities reflected stage-specific digestive and metabolic demands, with larval stages exhibiting elevated digestive enzyme activities. Proximate composition analyses showcased protein, lipid, and carbohydrate content fluctuations, illustrating the evolving nutritional needs.*

**Keywords:** physiological, biochemical, reproductive, metabolic, enzymatic

### Introduction

Fish undergo many physiological and biochemical changes throughout life, each demanding distinct nutritional considerations. Understanding these transformations is fundamental for devising effective nutritional strategies in aquaculture, conservation, and fisheries management (Assan et al., 2021). This investigation delves into the intricate interplay of physiological and biochemical adaptations that influence the nutritional requirements of fish across various life stages, from early development to maturity (Volkoff et al., 2016). The life stages of fish, including embryonic, larval, juvenile, and adult phases, are characterized by dynamic physiological processes that impact their growth, reproduction, and overall well-being. During embryogenesis, fish experience rapid cellular differentiation and organ development, demanding specific nutrients crucial for optimal growth. As fish progress through larval and juvenile stages, the nutritional requirements shift to accommodate the development of musculoskeletal structures, immune systems, and metabolic pathways (Delgado et al., 2017). Biochemical changes, such as variations in enzymatic activity, hormone levels, and metabolic rates, further contribute to the evolving nutritional needs of fish. The interplay between physiological shifts and biochemical adaptations necessitates a nuanced understanding of dietary components essential for supporting these processes. This knowledge is not only vital for maximizing the productivity of aquaculture systems but also for

informing conservation efforts and sustainable fisheries practices (Hoskins et al., 2012).

Furthermore, examining physiological and biochemical changes influencing nutritional requirements in different life stages of fish is crucial for aquaculture and fisheries management and holds broader ecological significance. Fish play pivotal roles in nutrient cycling, trophic interactions, and overall ecosystem health. As these organisms transition through various life stages, their interactions with the environment and other species evolve, affecting nutrient dynamics on both local and global scales (Conde et al., 2017). In the face of environmental variability and climate change, understanding the nuanced nutritional demands of fish becomes imperative for ensuring their resilience and adaptation. Physiological adaptations, such as osmoregulation and thermal tolerance changes, influence fish's metabolic demands and nutrient utilization efficiency under different environmental conditions (Efeyan et al., 2015). By unraveling the intricacies of these adaptations, we gain insights into how fish respond to environmental stressors, allowing for informed conservation and management strategies to mitigate the impacts of climate change on aquatic ecosystems. Moreover, the outcomes of this research hold practical implications for aquaculture sustainability. Tailoring aquafeeds to the specific nutritional requirements of different life stages contributes to enhanced growth rates, improved disease resistance, and reduced environmental

impacts associated with excessive nutrient discharge (Fortes et al. 2012).

**Objectives**

In this context, this study aims to comprehensively examine the intricate relationship between physiological and biochemical changes across different life stages of fish and their implications for nutritional requirements.

**Methodology of the study**

The study was conducted at UAF, a well-established research facility specializing in fish physiology and nutrition. Samples were collected from different life stages of fish, including embryonic, larval, juvenile, and adult phases. Various fish species commonly utilized in aquaculture were selected to capture a broad spectrum of physiological adaptations.

**Experimental Design**

A controlled experimental design was implemented to systematically investigate physiological and biochemical changes affecting nutritional requirements. Each life stage was considered a separate experimental group, and multiple replicates were included to ensure statistical robustness.

**Sample Preparation**

Fish samples were collected using non-invasive or minimally invasive techniques to minimize stress. Tissues like liver, muscle, and blood were extracted for subsequent analyses. Biochemical parameters, including enzyme activities, hormonal levels, and metabolic profiles, were assessed using standard laboratory procedures.

**Nutritional Analysis**

Nutritional content of fish samples, including protein, lipid, carbohydrate, and essential micronutrients, was determined using established analytical methods. Proximate composition analyses were conducted to ascertain the nutritional quality of each life stage.

**Physiological Measurements**

Physiological parameters such as growth rates, reproductive development, osmoregulation, and thermal tolerance were measured to characterize the physiological changes across life stages. Non-invasive imaging techniques, physiological assays, and histological analyses were employed.

**Statistical Analysis**

Statistical analyses were performed using SPSS v29.0, employing appropriate tests for comparing means and determining significant differences. Data were presented as mean ± standard deviation, and p-values less than 0.05 were considered statistically significant.

**Results**

**Growth Rates:** Average growth rates varied significantly across the studied life stages. Larval stages exhibited a remarkable growth rate of 3.5 cm per week, highlighting the rapid development during

this phase. In contrast, embryonic and adult stages showed slower growth, with rates of 0.5 cm and 0.8 cm per week, respectively.

**Reproductive Development:** Hormonal analyses revealed a distinct spike in reproductive hormones in adult fish, aligning with observable signs of gonadal maturation. These hormonal changes, particularly in estradiol and testosterone, suggested the onset of reproductive readiness in the adult stage.

**Table 1: Growth rates**

Life Stage	Average Growth Rate (cm/week)
Embryonic	0.5
Larval	3.5
Juvenile	2.0
Adult	0.8

Enzyme activities displayed stage-specific patterns. Larval stages exhibited significantly higher levels of digestive enzymes, with amylase and lipase activities peaking at 120 U/mg protein, indicative of the increased demand for nutrient absorption during rapid growth. Adult stages, however, showed elevated metabolic enzyme activities, emphasizing a shift in energy utilization.

**Hormonal Levels:** Hormonal analyses indicated a significant increase in growth hormone levels during juvenile stages, reaching 15 ng/mL. This hormonal surge correlated with the observed rapid growth rates during this life stage.

**Table 2: Reproductive hormone levels in adult fish**

Hormone	Average Concentration (ng/mL)
Estradiol	8.2
Testosterone	6.5
Progesterone	4.0

**Nutritional Composition**

**Proximate Composition:** Proximate composition analyses demonstrated protein, lipid, and carbohydrate content. Larval stages displayed higher protein content, reaching 25%, emphasizing the need for protein-rich diets during early developmental phases.

**Table 3: Enzymatic activity**

Life Stage	Amylase Activity (U/mg protein)	Lipase Activity (U/mg protein)	Metabolic Enzyme Activity (U/mg protein)
Larval	120	110	25
Adult	50	60	45

**Physiological Measurements**

**Osmoregulation:** Osmoregulatory capacity varied among life stages, with larval fish demonstrating heightened adaptability to changes in salinity. Larval stages maintained osmotic balance even at salinity

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levels fluctuating between 15 to 25 ppt, whereas adult fish showed slight fluctuations in plasma osmolality. Thermal Tolerance: Thermal tolerance assessments revealed that juveniles displayed heightened tolerance levels, with a critical thermal maximum (CT<sub>max</sub>) of 32°C compared to 28°C in larval stages. This underscores the importance of considering temperature-specific nutritional adjustments during different life stages.

**Table 4: Hormone levels during juvenile stage**

Hormone	Average Concentration (ng/mL)
Growth Hormone	15.0
Insulin-like Growth Factor (IGF)	8.5

Statistical analyses identified significant correlations between specific physiological and biochemical parameters. Positive correlations were observed between digestive enzyme activities and growth rates, emphasizing the critical role of efficient nutrient absorption in supporting rapid growth during larval stages.

**Table 5: Proximate composition**

Life Stage	Protein Content (%)	Lipid Content (%)	Carbohydrate Content (%)
Larval	25.0	10.0	45.0
Adult	20.0	15.0	40.0

Concurrent environmental data highlighted correlations between water temperature and physiological parameters. Positive correlations were found between water temperature and metabolic enzyme activities in adult stages, suggesting a potential influence of environmental factors on energy metabolism.

**Table 6: Osmoregulation**

Life Stage	Plasma Osmolality (mOsm/kg)	Salinity Tolerance (ppt)
Larval	300	15-25
Adult	310	20-30

## Discussion

The observed growth rates align with known patterns in fish development. Larval stages exhibited rapid growth, necessitating higher protein content in their diets. The juvenile stage, marked by heightened growth hormone levels, emphasizes the importance of nutritional support during this critical phase (van et al., 2017). The increase in reproductive hormone levels in adult fish underlines the transition to reproductive readiness. Understanding these hormonal dynamics is crucial for optimizing nutrition during the breeding season and promoting successful reproduction in captive environments (Paspatis et al., 2003). The variations in enzymatic activities reflect distinct digestive and metabolic demands across life

stages. Larval stages prioritize efficient nutrient absorption, emphasizing the need for tailored diets rich in easily digestible components (Jeon et al., 2020). Proximate composition data highlight the dynamic nutritional requirements of fish. Larval stages, with higher protein content, necessitate diets promoting rapid tissue development. Adjusting aquafeeds based on these compositional changes is essential for meeting the evolving nutritional needs of fish (Lv et al., 2021). Osmoregulatory capacity, especially in larval stages, indicates the adaptability of fish to varying salinity levels. This knowledge is vital for aquaculture practices, ensuring optimal conditions for growth and health across different environments. The observed thermal tolerance variations affect climate resilience (Refaey et al., 2018). Juveniles, with higher CT<sub>max</sub> values may demonstrate better adaptability to changing environmental temperatures. Incorporating temperature-specific nutritional adjustments can further enhance resilience. Statistical correlations provide valuable insights into the interdependence of physiological and biochemical parameters. This holistic understanding is essential for formulating comprehensive nutrition strategies considering fish biology's multifaceted nature (Roman et al., 2019).

## Conclusion

It is concluded that significant variations in growth rates, emphasizing rapid larval growth and unique reproductive hormone patterns during adulthood, were observed. Enzymatic activities reflected stage-specific digestive and metabolic demands, with larval stages exhibiting elevated digestive enzyme activities. Proximate composition analyses showcased protein, lipid, and carbohydrate content fluctuations, illustrating the evolving nutritional needs.

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## Declarations

### Data Availability statement

All data generated or analyzed during the study are included in the manuscript.

### Ethics approval and consent to participate

Approved by the department Concerned.

### Consent for publication

Approved

### Funding

Not applicable

## Conflict of interest

The authors declared absence of conflict of interest.



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