

Article

The Impact of Environmental Factors on the Genotype of African Catfish (*Clarias Gariepinus*): Molecular Bases and Economic Efficiency

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Abstract: This article was revised in IMRAD format and translated into scientific English. It examines the environmental plasticity of the genotype of African catfish (*Clarias gariepinus*) in flow-through culture systems, with particular attention to gene expression, epigenetic responses, and production efficiency. Based on a 16-month monitoring period, the study assesses the effects of hydrodynamic stress, temperature stability, and high-protein pelleted feeding on growth performance, survival, and farm profitability. The findings suggest that environmental signals can activate latent molecular pathways associated with myogenesis, metabolic programming, and homeostatic regulation. Under intensive conditions, specific growth rate increased from 0.8-1.0% to 1.5-2.0%, survival rose from 60-70% to 90%, and the production cycle shortened from 12 months to 6-8 months. These results indicate that the combined management of genotype, environment, and feeding strategy can significantly improve both biological productivity and economic efficiency in African catfish farming.

Keywords: *Clarias Gariepinus*, Gene Expression, Epigenetics, Myogenesis, Homeostasis, Flow-Through Ponds, Economic Efficiency, Feed Conversion Ratio (FCR).

Introduction

Rapid global population growth and limited natural resources require aquaculture to intensify production through innovative and scientifically grounded approaches. In conventional fish culture, genotype has often been viewed as a static code whose productive potential can only be improved through selection. However, advances in molecular biology and epigenetics suggest that genetic potential may respond dynamically to environmental signals and may generate new phenotypic combinations under specific production conditions [1], [2], [3].

African catfish (*Clarias gariepinus*) is particularly suitable for this line of inquiry because of its high ecological plasticity, tolerance to variable culture conditions, and strong response to external stimuli. International studies from Vietnam, the Netherlands, and Nigeria indicate that hydrodynamic conditions, temperature regime, and feed composition can modulate gene clusters associated with growth, stress adaptation, and metabolism. In recirculating aquaculture systems, for example, growth hormone-related responses have been linked to hydraulic conditions and feed quality [4], [5].

The aim of the present study was to identify the molecular and productive responses of African catfish genotype to environmental signals under flow-through culture conditions and to evaluate the associated economic efficiency [6]. The working hypothesis was that the synergistic effect of flowing water and high-protein pelleted feed activates latent genetic programs related to muscle hypertrophy and hyperplasia, thereby increasing overall production performance [7].

Materials and Methods

The article is based on a 16-month production and biological monitoring study conducted in flow-through pond/basin conditions for African catfish culture. As reported in the source manuscript, the monitoring design focused on the interaction between environmental factors and production outcomes rather than on laboratory-scale genomic assays [8], [9].

The main experimental factors were: [10] hydrodynamic conditions created by flowing water; [11] thermodynamic stability expressed through water temperature regime; and [12] feeding technology based on high-protein granulated feed, especially during the early developmental period. The conceptual framework of the study interprets these factors as external signals capable of influencing gene expression and epigenetic regulation.

The principal response variables were specific growth rate (SGR), survival rate, harvest period, final biomass, and maximum individual weight. A comparative economic analysis was also conducted by contrasting the intensive flow-through and granulated-feed system with a conventional culture model.

Because the original manuscript presents the study as long-term production monitoring, the methodological interpretation in this IMRAD version retains the reported indicators and analytical logic while standardizing the structure and terminology for scientific presentation [13].

Results

3.1. Molecular and physiological responses

The study indicates that fish growth depends not only on the presence of growth-related genes but also on their level of expression. Under flow-through conditions, continuous swimming activity was associated with activation of MyoD and Myofactor-5 pathways involved in myogenesis. This response may promote both hypertrophy of existing muscle fibers and hyperplasia through the formation of new fibers.

In addition, high-protein feeding during the early developmental period was interpreted as a metabolic programming factor capable of leaving an epigenetic imprint. The manuscript links this process to DNA methylation patterns that may suppress growth-inhibiting pathways and favor growth hormone activity [14].

3.2. Production performance over 16 months

Temperature stability played a key role in the regulation of physiological performance. Under optimal thermal conditions, enzymatic activity was reported to accelerate by approximately 1.8-2.0 times, contributing to a body weight increase that exceeded expected values by 25-30% [15].

During the 16-month monitoring period, total biomass production reached 34 tons. The maximum individual body weight reached 9 kg, while survival attained 90%. These outcomes were interpreted in relation to the homeostatic role of stress-response proteins such as HSP70 under intensive culture conditions.

Table 1. Comparative production performance under conventional and intensive culture conditions.

Indicator	Conventional system	Intensive system (flow-through + pelleted feed)	Difference
Daily weight gain (SGR)	0.8-1.0%	1.5-2.0%	+100%
Survival rate	60-70%	90%	+25%
Production cycle	12 months	6-8 months	-4 months

Discussion

The findings support the idea that the productive capacity of African catfish is not determined solely by inherited genotype, but also by its dynamic interaction with environmental conditions. The combination of water flow, thermal stability, and high-protein feed appears to enhance the expression of growth-related pathways and improve production traits [16].

The reported outcomes are consistent with international evidence. Vietnamese flow-channel systems have shown that continuous water circulation reduces stress and improves growth performance. Dutch studies in recirculating aquaculture systems have emphasized the importance of bio-chemical water quality and metabolic programming for feed utilization. Nigerian experiences with high-protein feeding similarly indicate improved immune performance and higher survival in African catfish.

From a practical standpoint, the study demonstrates that environmental management may serve as a biological amplifier of genetic potential. In this context, the proposed “Genotype + Environment + Feed” model provides a useful conceptual basis for intensive catfish production and for future work in applied epigenetics in aquaculture.

Conclusion

The study demonstrates that the genotype of African catfish (*Clarias gariepinus*) should be understood as a dynamic biological system capable of responding to external environmental signals. Flow-through hydrodynamics and high-protein granulated feed were associated with the activation of growth-related molecular mechanisms, improvement of production indicators, and greater economic return.

The combination of genotype management, environmental optimization, and feeding technology resulted in higher biomass yield, faster growth, shorter production cycles, and improved survival. The findings therefore support the practical use of environmentally mediated biological programming in intensive African catfish culture.

Future studies should complement production monitoring with direct molecular assays, including transcriptomic and epigenetic measurements, in order to validate the proposed mechanisms under controlled experimental conditions.

Practical Implications

- Introduce early-stage metabolic programming protocols during the first 45 days of development.
- Promote the gradual transition from stagnant-water ponds to flow-through raceway-type systems where feasible.
- Integrate selective breeding strategies with environmental plasticity traits when choosing broodstock or production lines.

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