Advances and Current Developments in Larval Rearing of Catfish

Amit Kumar[1], Md Meraj[1*], Rohit Kumar[2], Lavish Saran[3] and Ashish Singh[4]

[1]College of Fisheries, Dholi, Muzaffarpur, Bihar- 843121

[2]Division of Aquaculture, ICAR- CIFE, Maharashtra - 400061

[3]College of Fisheries Science, Hisar, Haryana-125004

[4]Research Assistant, ICAR- CIFRI, Prayagraj- 211002

*Corresponding author

Email address: mdmeraj8858@gmail.com

Abstract

Catfish aquaculture, pivotal for global food security, faces critical bottlenecks in larval rearing due to high mortality from physiological vulnerabilities and environmental stressors. This review synthesizes recent advances transforming larviculture, including microdiets enriched with essential fatty acids and probiotics to replace live feeds like Artemia, alongside hatchery innovations such as recirculating aquaculture systems (RAS), biofloc technology and automated environmental controls. Integration of IoT sensors and AI-driven predictive models enables real-time monitoring, anomaly detection and optimized feeding, boosting survival rates (e.g., 40% improvement in Nigerian *Clarias gariepinus* hatcheries). Country-specific case studies from India, Vietnam, Nigeria and the US highlight tailored biosecurity protocols, hybrid strains and molecular diagnostics. Persistent challenges nutritional fine tuning, biosecurity risks and cost barriers underscore the need for genomics, nanoencapsulation and supportive policies to ensure sustainable, scalable catfish production.

Keywords: Catfish larviculture, Microdiets, RAS, Biofloc technology, AI in aquaculture

Introduction

Aquaculture has emerged as a critical contributor to global food security, with catfish farming playing a prominent role due to the biological resilience and economic value of species such as *Clarias* spp., *Pangasianodon hypophthalmus*, and *Ictalurus punctatus*. While grow-out technologies for catfish have advanced substantially, larval rearing remains a decisive bottleneck influencing overall production efficiency. Early life stages are

characterized by rapid physiological changes, underdeveloped digestive systems, and heightened sensitivity to environmental stressors, which collectively contribute to high mortality and variable growth performance (Gisbert et al., 2022).

Recent progress in catfish larviculture has increasingly focused on optimizing early nutritional regimes, particularly through improved use of live feeds during first feeding and the strategic transition to formulated microdiets designed to match the progressive development of larval digestive functionality (Gisbert et al., 2022; Tola et al., 2021; Kemigabo et al., 2019). In parallel, innovations in hatchery system design such as recirculating aquaculture systems and improved water quality management have enhanced larval survival and uniformity. Moreover, the integration of microbial management and automation technologies is gaining attention for reducing disease outbreaks and labour dependency while ensuring consistent rearing conditions. Collectively, these developments highlight a shift toward more controlled, knowledge-driven larviculture practices, positioning larval rearing as a key focus for sustainable expansion of the global catfish industry.

Traditional Larval Rearing Techniques

Historically, catfish larval production has been dominated by conventional hatchery practices based on hormonally induced spawning, followed by larval rearing in static or semi-static systems such as earthen ponds and concrete tanks. Spawning is commonly achieved through the administration of pituitary extracts or commercially available synthetic hormones, after which newly hatched larvae are transferred to fertilized ponds or indoor tanks for early rearing (Khan et al., 2023; Talib & Mahmud, 2017).

Traditional larval rearing systems rely heavily on live feeds, including *Artemia* nauplii, *Moina*, *Daphnia*, and other zooplankton, to support first feeding and early growth. Although live feeds provide high digestibility and favorable nutrient profiles, their use is frequently associated with challenges related to water quality deterioration, microbial proliferation, and inconsistent availability. Recent studies from Southeast Asia, including the Philippines, indicate that continued reliance on zooplankton-based feeding in *Clarias* hatcheries often results in variable larval survival and growth, largely due to fluctuations in water quality and live-feed supply (Vu & Huynh, 2020; Santiago et al., 2017).

Advances in Larval Nutrition

Microdiets and Formulated Feeds

With the rising cost and biosecurity risks associated with live feeds, the development of formulated microdiets has emerged as a promising alternative. Microdiets are specifically designed to meet the nutritional requirements of larval fish and can be tailored for specific species. These diets usually contain a blend of protein sources, essential fatty acids (especially EPA and DHA), vitamins, and mineral premixes that ensure proper skeletal and organ development. Studies have demonstrated the effectiveness of replacing live feeds with enriched microdiets. For instance, Hamre et al. (2013) found that larvae fed on microencapsulated diets showed improved growth and resistance to stress, provided that the feeds were palatable and appropriately sized.

Live Feed Enrichment

Although formulated feeds are gaining ground, live feeds remain indispensable during the earliest stages. The practice of enriching live feeds with essential fatty acids, vitamin C, selenium, and probiotics helps bridge the nutritional gap between natural and artificial diets. For example, Artemia enriched with DHA-rich emulsions significantly enhances survival and growth rates in catfish larvae. Depending on species and stage:
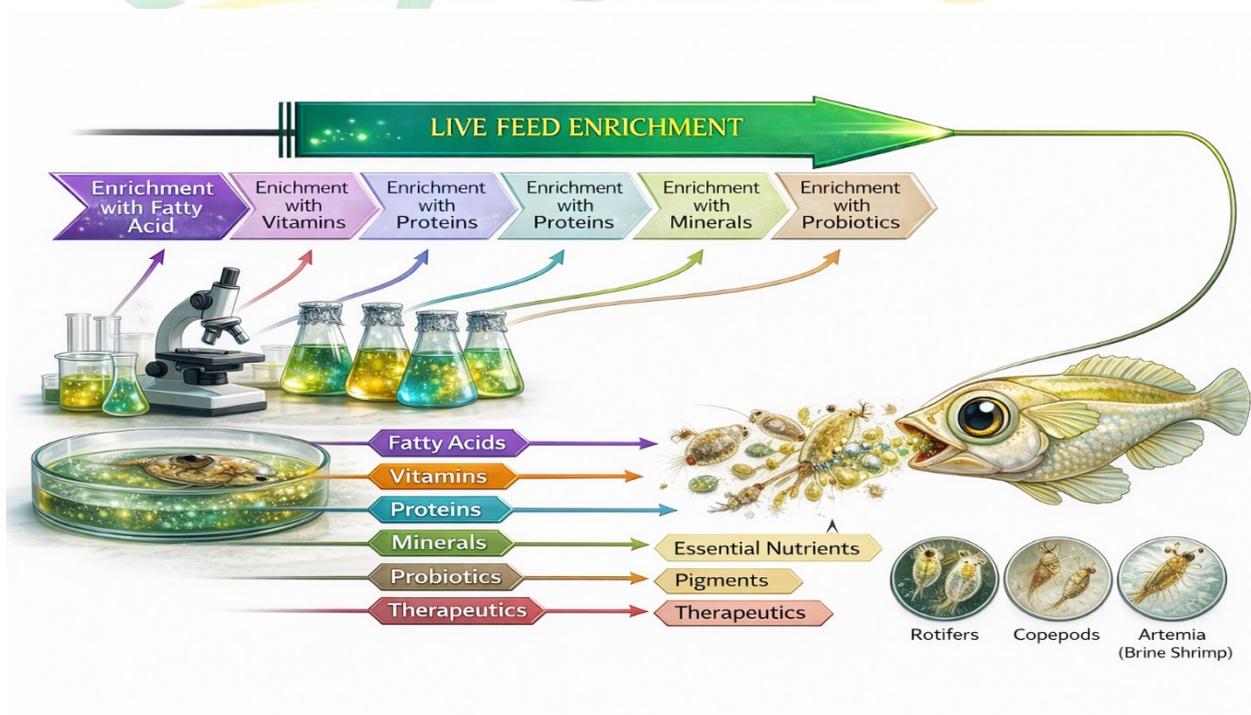

Fig 1. Live Feed Enrichment

Role of Probiotics and Prebiotics

Probiotics and prebiotics are increasingly incorporated into larval diets to promote gut health, reduce pathogenic load, and improve digestion. Common probiotic strains include *Bacillus subtilis*, *Lactobacillus acidophilus*, and *Saccharomyces cerevisiae*, which colonize the gut and enhance immunity. Prebiotics such as mannan-oligosaccharides serve as a food source for beneficial bacteria and have shown promise in reducing larval deformities and increasing feed conversion ratios (Gisbert et al., 2022).

Hatchery System Innovations

Recirculating Aquaculture Systems (RAS)

RAS technology has revolutionized hatchery operations by providing a closed-loop system where water is continuously filtered and reused. Key advantages include reduced water usage, biosecurity, and consistent environmental conditions, which are crucial for sensitive larval stages. In *Clarias gariepinus* hatcheries in Nigeria, the adoption of recirculating aquaculture systems has been shown to significantly enhance larval survival compared with static systems, primarily through improved regulation of ammonia concentration, dissolved oxygen, and temperature stability (Isaiah & Shauntell, 2019; Onuwa & Charles, 2023).

Biofloc Technology

Biofloc technology involves cultivating microbial aggregates that convert waste nitrogen into microbial biomass, which serves as supplemental nutrition, enhances immune responses in fish larvae, and promotes a stable microbial community that suppresses pathogenic bacteria. In South Asia, particularly in India and Bangladesh, biofloc systems have been successfully adopted in small-scale hatcheries to improve larval performance and health status (Shamsuddin et al., 2022).

Environmental Control

Automated control of photoperiod and water temperature can significantly influence larval development. Light regimes affect the visual feeding behavior of larvae, while temperature influences metabolic rates. Integrated control systems ensure optimal growth conditions by modulating these parameters in real time (Romanova & Romanov, 2020).

A Multidisciplinary Peer-Reviewed E-Magazine

Vol. 01, Issue 01, January 2026

AgroLife FRONTIERS
https://agrolifefrontiers.in

ALF/ART/001

Kumar et al. (2026)

Table 1. Recommended Environmental Parameters for Catfish Larvae

Parameter	Optimal Range
Temperature	27–30°C
Dissolved Oxygen	>5 mg/L
pH	6.5–7.5
Ammonia (NH3)	<0.05 mg/L
Nitrite (NO2)	<0.5 mg/L
Light	500–1000 lux (species-dependent)

Automation and AI Integration

Smart Monitoring Tools

Advancements in sensor technology and data analytics have enabled real-time monitoring of water quality parameters such as pH, dissolved oxygen, and turbidity. Sensors connected via the Internet of Things (IoT) can relay data to cloud-based dashboards, enabling hatchery operators to act swiftly and prevent larval mortality.

Machine Learning and Predictive Models

Artificial intelligence (AI) applications are gaining traction in larval rearing. Predictive models can forecast larval growth, feed requirements, and detect anomalies in behavior indicative of stress or disease. These models learn from historical datasets to optimize feeding schedules, leading to better resource utilization and reduced waste.

An experimental hatchery in Vietnam, the use of AI for monitoring larval behaviour helped detect a protozoan in outbreak two days earlier than manual inspection, saving over 70% of the larval batch.

Country-Specific Developments and Case Studies

India

India has become a hub for catfish hatchery innovation. The Central Institute of Freshwater Aquaculture (CIFA) has developed species-specific larval diets and strengthened hatchery biosecurity protocols. State governments have also supported the adoption of recirculating

aquaculture systems and capacity-building programs to enhance rural aquaculture development. Recent studies conducted under Indian hatchery conditions indicate that the integration of functional feed additives, including prebiotics, with improved hatchery management and energy-efficient systems can substantially enhance larval survival and robustness (Ferose Khan et al., 2021).

Vietnam

Vietnam's Pangasius industry is one of the largest in the world. Innovations include the use of hybrid lines with improved growth and stress tolerance. Commercial hatcheries employ temperature-controlled RAS systems, automated grading machines, and AI-powered environmental controls to enhance larval uniformity.

Nigeria

In Nigeria, public-private partnerships have facilitated the widespread adoption of earthen and biofloc tank systems for *Clarias gariepinus*. Hatcheries employing probiotic-treated feeds and improved spawning protocols report increased hatchability and better yolk sac absorption among larvae (Mosha et al., 2018).

United States

U.S. Hatcheries have pioneered in using molecular diagnostics for disease management in *Ictalurus punctatus*. Integration of AI-driven feeding systems has allowed precise larval nutrition management. Research institutions collaborate with hatcheries to develop pathogen-resistant strains and probiotic-supplemented larval diets.

Challenges and Future Prospects

Despite the advances, several challenges persist:

➢ Nutritional bottlenecks: Fine-tuning micronutrient composition in microdiets remains complex, especially for different developmental stages.
➢ Biosecurity risks: Open systems are still prone to pathogen introduction.
➢ Cost barriers: Small-scale farmers often cannot afford advanced systems.

Future research should focus on:

➢ Genomics for selecting robust larval lines.
➢ Nanoencapsulation of nutrients for better bioavailability.

> Policy frameworks to support technology adoption in developing regions.

Conclusion

Larval rearing remains a vital yet challenging component of catfish aquaculture. The last decade has witnessed substantial progress in larval feed formulation, hatchery system innovations, and the adoption of AI technologies. These advancements have significantly improved survival rates, growth performance, and production efficiency. However, to achieve truly sustainable catfish aquaculture, continued research, farmer training, and equitable access to technology are essential.

References

Ferose Khan, S., Sahoo, S. N., Giri, S. S., & Sahoo, S. K. (2021). Scenario of captive production of Clarias magur in India. Aquaculture Asia, 25(1), 10-13.

Gisbert, E., Luz, R. K., Fernández, I., Pradhan, P. K., Salhi, M., Mozanzadeh, M. T. & Darias, M. J. (2022). Development, nutrition, and rearing practices of relevant catfish species (Siluriformes) at early stages. Reviews in Aquaculture, 14(1), 73-105.

Hamre, K., Yúfera, M., Rønnestad, I., Boglione, C., Conceição, L. E., & Izquierdo, M. (2013). Fish larval nutrition and feed formulation: knowledge gaps and bottlenecks for advances in larval rearing. Reviews in Aquaculture, 5, S26-S58.

Isaiah, A. K., & Shauntell, O. O. (2019). Studies on the hatchability, growth performance and survival of African catfish (Clarias gariepinus) in different aquaculture production systems.

Kemigabo, C., Jere, L. W., Sikawa, D., Masembe, C., Kang'ombe, J., & Abdel-Tawwab, M. (2019). Growth response of African catfish, Clarias gariepinus (B.), larvae and fingerlings fed protease-incorporated diets. Journal of Applied Ichthyology, 35(2), 480-487.

Khan, A. B. S., Akhter, M., & Modak, S. R. (2023). Artificial propagation of Asian catfish, Clarias batrachus (Linnaeus, 1758) in Asia: A review. Archives of Agriculture and Environmental Science, 8(1), 92-96.

Mosha, S. S. (2018). Recent comparative studies on the performance and survival rate of African catfish (Clarias gariepinus) larval produced under natural and synthetics hormones.

Onuwa, G. C., & CHARLES, A. (2023). Comparative Development of Juvenile Catfish (Clarias Gariepinus) Fed Commercial Diets and Maggot Meal in Recirculating Aquaculture System. Malaysian Animal Husbandry Journal, 3(2), 56-60.

Romanova, E. M., & Romanov, V. V. (2020). Increase in nonspecific resistance of catfish (Clarias gariepinus) in industrial aquaculture. BIO Web of Conferences, 17, 00122.

Shamsuddin, M., Hossain, M. B., Rahman, M., Kawla, M. S., Shufol, M. B. A., Rashid, M. M., ... & Rakib, M. R. J. (2022). Application of Biofloc Technology for the culture of Heteropneustes fossilis (Bloch) in Bangladesh: stocking density, floc volume, growth performance, and profitability. Aquaculture International, 30(2), 1047-1070.

Talib, E. A. H., & Mahmud, Z. N. E. D. (2017). Breeding Practices and rearing response of Clarias gariepinus under hatchery condition. Research Journal of Agriculture and Environmental Management Vol, 6(5), 089-094.

Tola, S., Jintasathaporn, O., & Yuangsoi, B. (2021). Successful nursing of Mekong giant catfish (Pangasianodon gigas, Chevey 1930) larval by replacing live feed with microcapsule diet. Aquaculture, 534, 736293.

Vu, N. U., & Huynh, T. G. (2020). Optimized live feed regime significantly improves growth performance and survival rate for early life history stages of pangasius catfish (Pangasianodon hypophthalmus). Fishes, 5(3), 20.