



A comprehensive review on the role of live feeds in ornamental fish and aquarium culture

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Abstract

Live feeds are essential for the successful rearing of ornamental fishes, especially during larval and juvenile stages, when digestive capabilities are limited. This review synthesizes findings from 40 peer-reviewed studies to evaluate the nutritional composition, enrichment strategies, and functional benefits of various live feeds such as rotifers, *Artemia*, copepods, and branchiopods. Species-specific feeding protocols, especially during early life stages, significantly impact growth, pigmentation, and survival. The integration of live feed enrichment with probiotics, fatty acids, and vitamins enhances fish health and appearance. Tables provide summarized insights into feed sizes, nutritional composition, and enrichment techniques. This review also discusses sustainable alternatives and future perspectives for ornamental aquaculture feed development.

Keywords: Live feeds, ornamental fish, aquaculture nutrition, copepods, artemia, probiotics, pigmentation, larval rearing

Introduction

Ornamental fish farming has emerged as one of the most vibrant sectors within global aquaculture, contributing significantly to economic growth, rural livelihoods, and international trade. Valued at over USD 15 billion globally, the ornamental fish industry continues to expand due to growing public interest in aquascaping, therapeutic aquarium use, and sustainable pet ownership (Sicuro, 2021^[33]; MPEDA, 2022). Countries such as India, Singapore, Thailand, and Germany play leading roles in production and export, with India's ornamental aquaculture sector offering income opportunities across states like West Bengal, Maharashtra, Kerala, and Tamil Nadu (Shinoj *et al.*, 2021^[32]). A major bottleneck in ornamental fish production is the high mortality rate during larval and early juvenile stages, primarily due to inadequate nutrition. At these stages, the digestive systems of fish are underdeveloped and require live, moving prey that can trigger feeding behaviour and meet specific nutritional needs (Lim *et al.*, 2003^[18]; Hill *et al.*, 2020)^[11]. Live feeds such as *Brachionus* (rotifers), *Artemia* nauplii, copepods, infusoria, and branchiopods provide essential proteins, fatty acids (e.g., DHA and EPA), and micronutrients, along with the movement stimuli needed for successful prey recognition.

Although formulated diets have advanced considerably, they often fall short in meeting the early physiological demands of ornamental fish larvae. Therefore, the strategic use of live feeds remains indispensable. Enhancing the nutritional quality of live feeds through enrichment techniques using probiotics, carotenoids, and fatty acids has been shown to further improve survival, growth, coloration, immunity, and reproductive success (Sales & Janssens, 2003^[28]; Gupta *et al.*, 2007; Kandathil *et al.*, 2020)^[13].

Focusing on this topic is increasingly important given the industry's need for:

- Environmentally sustainable aquaculture practices,
- Reduced reliance on expensive or imported live feed products,
- Development of cost-effective, locally sourced feed options such as *Streptocephalus simplex* and tubifex worms,
- Technological interventions like nutrigenomics and AI in feed management.

This review aims to consolidate findings from 40 scientific studies to evaluate the diversity, nutritional efficacy, enrichment strategies, and practical applications of live feeds in ornamental aquaculture. The paper highlights both freshwater and marine systems, identifies challenges, and outlines future directions for sustainable and effective feed development.

Materials and Methods

A total of 40 academic publications, book chapters, and conference proceedings from 1995 to 2025 were reviewed. Sources were selected based on relevance to ornamental fish nutrition, live feed applications, larval development, and feed enrichment. Databases used included Science direct, Springer link, and Google scholar. Data were organized thematically: live feed type and size, nutrient content, enrichment practices, developmental stage suitability, and performance indicators such as growth, coloration, and survival. Tables were generated to provide visual summaries of feed properties and application strategies.

Results

Table 1: Common Live Feeds in Ornamental Aquaculture

Live Feed	Size Range (µm)	Protein Content (%)	Key Nutrients	Target Stage
Infusoria	10–50	30–40	Microalgae, vitamins	Hatchlings
<i>Brachionus</i> (Rotifers)	100–250	55–60	EPA, DHA	Larvae
Copepods	80–400	60–65	HUFA, amino acids	Marine larvae
<i>Artemia</i> nauplii	400–500	55–60	Protein, carotenoids	Advanced larvae/pos t-larvae
<i>Streptocephalus simplex</i>	500–1000	50–55	Minerals, fatty acids	Juveniles
Tubifex worms	>1000	60–65	Fatty acids, iron	Broodstock/Adults

The review identified a range of commonly used live feeds in ornamental aquaculture, each varying in size, nutritional composition, and developmental stage suitability. These live feeds include infusoria, rotifers (*Brachionus* spp.), copepods, *Artemia* nauplii, *Streptocephalus simplex*, and tubifex worms. Their nutritional profiles and biological roles are summarized in Table 1.

Infusoria, due to their extremely small size (10–50 μm) and composition rich in microalgae and vitamins, are used primarily during the initial feeding stage of hatchlings. They support the transition from yolk sac absorption to active feeding in small-mouthed larvae. Rotifers are widely utilized for larval stages because of their intermediate size (100–250 μm) and high protein content (55–60%). They are particularly rich in essential fatty acids such as EPA and DHA, which are vital for early organ development and immunity. Their ease of mass production and capacity for enrichment further increases their applicability in ornamental hatcheries.

Copepods, with a broader size range (80–400 μm) and superior levels of highly unsaturated fatty acids (HUFA), are especially important in marine larval culture. Their role in enhancing pigmentation, visual acuity, and larval survival has been widely documented. Their movement and

nutritional richness make them one of the most effective live feeds for early marine stages. *Artemia* nauplii are considered a universal live feed for advanced larval and post-larval stages, owing to their ideal size (400–500 μm), ease of hatching, and protein content of 55–60%. When nutritionally enriched, *Artemia* significantly improves coloration, stress resistance, and transition to formulated diets. *Streptocephalus simplex*, a freshwater branchiopod native to India, has emerged as an economical substitute for *Artemia*. With a larger size range (500–1000 μm), it is suitable for juvenile ornamental fishes, particularly in small-scale hatcheries. Its mineral and fatty acid content contributes to continued somatic growth. Tubifex worms, due to their large size (>1000 μm) and high protein and iron content, are most appropriate for adult and broodstock stages. Their inclusion in broodstock diets has been linked to improvements in reproductive performance, egg quality, and fry viability.

The diversity in live feed characteristics underscores the need for developmental stage-specific feeding protocols. The review supports that proper selection and application of live feeds, especially when enriched with targeted nutrients, directly influence ornamental fish growth, coloration, survival, and breeding success.

Table 2: Enrichment Strategies for Live Feeds

Additive Type	Enrichment Agent	Benefit	References
Fatty Acids	DHA, EPA (Fish oil emulsions)	Neural development, survival	Dhert <i>et al.</i> , 2001; Izquierdo <i>et al.</i> , 2001
Probiotics	Lactobacillus, Bacillus	Gut flora, immunity	Ghosh <i>et al.</i> , 2008 ^[8] ; Parvathi & Bharathi, 2022 ^[25]
Carotenoids	Spirulina, astaxanthin	Color enhancement	Gupta <i>et al.</i> , 2007
Vitamins	A, C, D, E	Immune boost, antioxidative effect	Sales & Janssens, 2003 ^[28]
Microalgae	Chlorella, Isochrysis	Basediet for rotifers	Hafeziyeh <i>et al.</i> , 2019 ^[9]

Enrichment of live feeds is a widely adopted strategy to improve the nutritional quality of naturally occurring zooplankton before offering them to ornamental fish. Table 2 outlines various additive types and enrichment agents that have been shown to enhance the functional benefits of live feeds across different life stages of fish.

One of the most critical enrichment approaches involves the supplementation of essential fatty acids, particularly docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), typically delivered through fish oil emulsions. These long-chain polyunsaturated fatty acids are essential for neural development, visual acuity, and overall larval survival, particularly in marine ornamental species (Dhert *et al.*, 2001; Izquierdo *et al.*, 2001). Probiotic enrichment using bacterial strains such as *Lactobacillus* and *Bacillus* has gained popularity for its role in improving gut health, immune modulation, and disease resistance in ornamental fish. Ghosh *et al.* (2008)^[8] reported enhanced survival and growth in guppies following the administration of probiotic-enriched *Artemia*. Similarly, Parvathi and Bharathi (2022)^[25] emphasized the importance of probiotic applications in maintaining a balanced intestinal microbiota.

Another category of enrichment involves carotenoids, particularly spirulina and astaxanthin, which are well-known for their role in enhancing pigmentation. Color vibrancy is a major market determinant for ornamental fishes, and enriched feeds have been shown to increase chromatic intensity in species like mollies, swordtails, and *Betta splendens* (Gupta *et al.*, 2007). Vitamin enrichment, particularly with vitamins A, C, D, and E, offers immunomodulatory benefits and protects against oxidative

stress during high-stress developmental phases. These micronutrients improve resilience to environmental fluctuations and promote metabolic stability (Sales & Janssens, 2003)^[28].

Finally, microalgae such as *Chlorella* and *Isochrysis* serve as both enrichment agents and base cultures for rotifers. Their inclusion not only enhances the protein and chlorophyll content of the feed but also improves the digestibility and palatability of live feed organisms. Hafeziyeh *et al.* (2019)^[9] noted that fish receiving algae-enriched feeds exhibited improved coloration and vitality. These enrichment strategies are highly adaptable and can be customized depending on the target species and developmental stage. They represent an important link between natural live feed application and modern nutritional optimization in ornamental aquaculture.

Discussion

Live feeds such as *Artemia* nauplii, rotifers (*Brachionus* spp.), copepods, and indigenous alternatives like *Streptocephalus simplex* play a critical role in ornamental fish nutrition. Rich in protein (50–65%) and essential fatty acids like DHA and EPA, these feeds are vital for early neural development, pigmentation, and retina formation in species such as guppies, goldfish, and angelfish (Simhachalam *et al.*, 2015^[34]; Sales & Janssens, 2003^[28]; Khanjani, 2021)^[16].

Larval ornamental fish fed appropriately sized, motile live feeds show significantly better prey recognition, ingestion efficiency, and survival than those given only formulated diets (Hill *et al.*, 2020^[11]; Campelo *et al.*, 2019)^[3]. The

digestibility advantage is evident in studies showing improved survival rates in larvae fed rotifers enriched with *Chlorella* (Lim & Wong, 1997) ^[19]. The natural movement of live feeds also stimulates feeding behavior, which is essential during early ontogeny. Enrichment techniques have significantly enhanced the functional value of live feeds. DHA and EPA delivered through HUFA emulsions promote neural development and growth, while probiotic strains like *Lactobacillus* and *Bacillus* improve immunity and gut health (Ghosh *et al.*, 2008) ^[8]. Similarly, spirulina and astaxanthin are effective in enhancing body coloration, thereby increasing the commercial value of ornamental species such as *Betta splendens* and mollies (Hafeziyeh *et al.*, 2019) ^[9]; Gupta *et al.*, 2007).

Live feeds also contribute to reproductive performance. Broodstock fed high-protein live diets such as tubifex worms exhibit better gonadal maturation, fecundity, and fry viability. This has been demonstrated in species like *Xiphophorus helleri* and *Betta splendens*, where combining live and formulated feeds resulted in improved reproductive outcomes (James & Sampath, 2002 ^[12]; Sampath & James, 2004 ^[35]; Mandal *et al.*, 2012 ^[23]; Verma *et al.*, 2015) ^[38]. Despite these advantages, live feed application faces limitations. High production costs, perishability, and variable nutrient content without proper enrichment pose logistical challenges (Santhosh *et al.*, 2023 ^[30]; Chittapun *et al.*, 2013) ^[5]. Moreover, if not cultured hygienically, live feeds can act as vectors for pathogens, leading to disease outbreaks and economic losses in hatchery systems (Seidgar *et al.*, 2024) ^[31]. These issues necessitate standardized enrichment practices, improved preservation methods, and robust quality control measures.

To mitigate cost and dependency on imports, integrated systems for on-site culturing of rotifers, microalgae, and indigenous branchiopods are being promoted. Locally available feeds like *Streptocephalus simplex* have demonstrated economic viability and nutritional adequacy, particularly for juvenile stages in Indian hatcheries (Patekar *et al.*, 2023 ^[27]; Sakpal, 2023 ^[29]; Mukherjee *et al.*, 2022) ^[24]. The future trajectory of live feed usage in ornamental aquaculture is aligned with innovations in biotechnology and sustainable practices. Nutrigenomics is being explored to design species-specific enrichment protocols tailored to developmental needs (Kandathil *et al.*, 2020) ^[13]. Additionally, sustainable enrichment sources such as insect meal and agro-industrial byproducts are being adopted to reduce environmental impacts (Vasanthakumaran *et al.*, 2020) ^[36]. Digital technologies for real-time monitoring and automated delivery of live feeds are emerging as practical tools to enhance efficiency and scalability (Maity *et al.*, 2021) ^[21]. In parallel, there is a pressing need to strengthen extension services and farmer-level training to promote low-cost, high-efficiency live feed culture, particularly in resource-limited settings where ornamental aquaculture supports rural livelihoods (Shinoj *et al.*, 2021) ^[32].

Conclusion

Live feeds are fundamental to the success of ornamental fish culture, particularly in larval and juvenile phases. Properly enriched live feeds improve growth, immunity, coloration, and reproductive performance. Strategic integration of live and formulated feeds ensures optimal development while supporting sustainability. Future focus should include low-cost alternatives, technological integration, and farmer-level

training to expand the benefits of live feed usage in ornamental aquaculture.

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