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Comparative effects of artificial, live, and mosquito larvae-based feeds on growth and reproductive performance of *Poecilia reticulata* and *Gambusia affinis*

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Abstract
Mosquitoes are major vectors of several human diseases, and biological control using larvivorous fishes presents an eco-friendly alternative to chemical insecticides. This study evaluated the effects of artificial feed, live feed, and mosquito larvae feed on the growth and reproductive performance of two ornamental freshwater fishes, *Poecilia reticulata* (guppy) and *Gambusia affinis* (mosquito fish), under laboratory conditions over 90 days. Fry were acclimatized and randomly assigned to triplicate tanks (n = 20 per tank) for each feed treatment. Growth parameters—including absolute growth rate (AGR), weight gain, daily growth rate (DGR), specific growth rate (SGR), standard length—and relative fecundity were measured, and water quality was maintained within optimal ranges. Statistical analysis using one-way ANOVA followed by Tukey's HSD test revealed significant differences ($p < 0.001$) among feed treatments. Mosquito larvae feed significantly enhanced AGR, DGR, SGR, standard length, and relative fecundity in both species compared to live feed and artificial feed. In guppies, AGR reached 0.790 ± 0.083 g and standard length 4.3 ± 0.37 cm, while in *G. affinis*, AGR was 1.988 ± 0.026 g and standard length 4.3 ± 0.25 cm in the mosquito larvae feed group. These findings indicate that mosquito larvae serve as a highly nutritious diet, promoting superior growth and reproductive output in ornamental fishes. The study highlights the dual benefits of employing *P. reticulata* and *G. affinis* in integrated mosquito control programs, combining enhanced fish performance with effective biocontrol of mosquito populations.

Keywords: *Poecilia reticulata*, *Gambusia affinis*, mosquito larvae, ornamental fish, growth, fecundity, biological control, larvivorous fish

Introduction

Mosquitoes transmit major human diseases, including dengue, chikungunya, and malaria, especially in tropical environments with abundant stagnant water (Iqbal *et al*., 2023; Raha *et al*., 2023) [15]. Traditional chemical insecticides have decreased effectiveness due to resistance and environmental concerns (Bioflux Journal of Aquatic Biology & Fisheries, 2023). Biological control through larvivorous fish is an environmentally sustainable strategy that reduces chemical use and targets mosquito larvae directly (Diptera Research Journal, 2022; Entomology Journals, 2023).

Fishes such as *Gambusia affinis* and *Poecilia reticulata* are suitable for integrated mosquito control due to high predatory efficiency, rapid reproduction, and adaptability to different habitats (MDPI Ornamental Fish Nutrition, 2025; Mandal *et al*., 2025). Nutritional quality influences growth, survival, and reproduction, which are essential for effective larvivory (Abdul Khader & Altaff, 2021) [1]. Previous research indicates that live feeds often enhance growth and reproductive traits compared to artificial diets (Arce Uribe *et al*., 2018; PMC Review, 2023).

This study evaluates the effects of artificial feed, live feed (*Artemia*), and mosquito larvae feed on growth, DGR, SGR, length, and fecundity of *P. reticulata* and *G. affinis*, identifying optimal diets to enhance ornamental fish performance and mosquito larvicidal activity under laboratory conditions.

Materials and Methods

Experimental Fishes and Rearing Conditions

Healthy fry of *Poecilia reticulata* (0.26 ± 0.02 g) and *Gambusia affinis* (0.26 ± 0.01 g) were sourced from a local hatchery and acclimatized for 7 days in fiberglass tanks (50 L; 26 ± 1 °C; pH 7.2 ± 0.3; DO 6.5 ± 0.5 mg/L) (Abdul Khader & Altaff, 2021) [1]. Fish were fed a commercial powdered feed during acclimation.

Feed Treatments

Three types of feed were used to evaluate their effects on growth and reproduction:

1. **Artificial feed:** Commercial pellets with ~30% crude protein (MDPI Ornamental Fish Nutrition, 2025).
2. **Live feed:** *Artemia* nauplii enriched with vitamins (PMC Review, 2023)
3. **Mosquito larvae feed:** Laboratory-reared *Culex quinquefasciatus* larvae supplied daily (Entomology Journals, 2023).

Fish were randomly assigned to triplicate tanks (20 fry per tank per treatment) and fed twice daily (09:00, 16:00 h) for 90 days.

Growth Measurements

Fishes were sampled every 30 days to record growth parameters:

- **Body weight (g):** Measured using an electronic balance (±0.001 g).
- **Standard length (cm):** Measured from snout to caudal peduncle using a digital caliper (±0.01 cm).
- **Absolute growth rate (AGR, g):** Calculated as AGR=Wf−WiAGR = W_f - W_iAGR=Wf−Wi, where WfW_fWf is final weight and WiW_iWi is initial weight (Wang *et al*., 2020) [20].
- **Weight gain (mg/g/day)**, **daily growth rate (DGR, g/day), and specific growth rate (SGR, %/day):** were calculated according to standard formulas (El-Sayed, 2018; Ezhil *et al*., 2011) [5, 6].
- **Fecundity:** Relative fecundity (number of eggs per gram of female body weight) was determined at the end of the experiment (Bashir *et al*., 2020) [3].

Water Quality Management

Water quality parameters were monitored weekly to ensure optimum rearing conditions. Dissolved oxygen, pH, temperature, and ammonia levels were measured using portable meters (Hach, USA) (Tripathi *et al*., 2019) [19]. Partial water exchange (30%) was performed twice weekly.

Statistical Analysis

All data are expressed as mean ± SD. The effect of feed type on growth and reproductive parameters was analyzed using one-way Analysis of Variance (ANOVA)
followed by Tukey's HSD post hoc test to determine significant differences among treatments ($p < 0.05$) (Zar, 2010; Motulsky, 2022) [12, 22]. Statistical analyses were performed using SPSS software version 26.0 (IBM, USA).

Results

The present study evaluated the effect of artificial feed, live feed, and mosquito larvae feed on the growth and reproductive performance of two ornamental freshwater fishes, *Poecilia reticulata* (guppy) and *Gambusia affinis* (mosquito fish), over a period of 90 days. All experiments were performed in triplicate, and the data are expressed as mean ± SD. Significant differences were observed in all growth and reproductive parameters between feed treatments, consistent with previous research demonstrating diet impacts on ornamental fish biology (Abdul Khader & Altaff, 2021; Palitha Kithsiri *et al*., 2011; Anka *et al*., 2023) [1, 2, 14]

Growth Parameters of Guppy (*Poecilia reticulata*)

Absolute Growth Rate (AGR)

The initial weight of guppy fry was 0.260 ± 0.023 g. After 30, 60, and 90 days, the absolute growth rates in the mosquito larvae feed group were consistently higher (0.543 ± 0.036 g, 0.743 ± 0.099 g, 1.05 ± 0.026 g, respectively) compared to live feed (0.403 ± 0.012 g, 0.500 ± 0.041 g, 0.640 ± 0.033 g) and artificial feed (0.367 ± 0.033 g, 0.453 ± 0.029 g, 0.583 ± 0.017 g) (Table 1). The maximum overall growth was observed in the mosquito larvae feed group (0.790 ± 0.083 g), while the lowest was in the artificial feed group (0.323 ± 0.028 g). These findings align with studies showing higher growth performance in guppies fed nutrient-rich or live diets (Abdul Khader & Altaff, 2021; Anka *et al*., 2023) [1, 2]

Table 1: Absolute growth rate (g) of guppy fry on different days after administration of various feeds

Name of feed	Day 0	Day 30	Day 60	Day 90	Absolute growth (g)
Artificial feed	0.260 ±0.045	0.357 ±0.033	0.435 ±0.029	0.583 ±0.017	0.323 ±0.028
Live feed	0.380 ±0.028	0.500 ±0.041	0.640 ±0.033	0.640 ±0.033	0.403 ±0.012
Mosquito larvae feed	0.543 ±0.036	0.743 ±0.099	1.05 ±0.026	1.05 ±0.026	0.790 ±0.083

Weight Gain, Daily Growth Rate (DGR), and Specific Growth Rate (SGR)

The mosquito larvae feed group exhibited the highest weight gain (0.530 ± 0.012 mg/g/day), DGR (0.0059 ± 0.0027 g/day), and SGR (0.588 ± 0.014%), compared to live feed (weight gain: 0.120 ± 0.029 mg/g/day; DGR: 0.00133 ± 0.0006 g/day; SGR: 0.133 ± 0.0032%) and artificial feed (weight gain: 0.063 ± 0.024 mg/g/day; DGR: 0.0007 ± 0.00001 g/day; SGR: 0.070 ± 0.0017%). Significant diet effects on growth indices have been similarly documented, where diets with higher protein and live components improved growth metrics (Abdul Khader & Altaff, 2021; Palitha Kithsiri *et al*., 2011) [1, 14] (Table 2).

Table 2: Weight gain (mg/g/day), daily growth rate (g/day), and specific growth rate (%) in guppy

Name of feed	Initial weight (g)	Final weight (g)	Weight gain (mg/g/day)	DGR (g/day)	SGR (%)
Artificial feed	0.260 ±0.045	0.323 ±0.028	0.063 ±0.009	0.0007 ±0.00001	0.034 ±0.0008
Live feed	0.380 ±0.028	0.500 ±0.041	0.120 ±0.029	0.00133 ±0.0006	0.133 ±0.0032
Mosquito larvae feed	0.543 ±0.036	1.05 ±0.026	0.530 ±0.012	0.0059 ±0.0027	0.588 ±0.014

Standard Length

The initial length of guppy fry was 0.5 ± 0.1 cm. After 90 days, the mosquito larvae feed group exhibited the highest standard length (4.3 ± 0.37 cm), followed by live feed (3.2 ± 0.34 cm) and artificial feed (1.9 ± 0.10 cm) (Table 3). Studies on ornamental fishes have shown that increased dietary protein and live feed generally enhance length growth, supporting our observations (Abdul Khader & Altaff, 2021) [1] (Table 3)

Table 3: Standard length (cm) of guppy fry on different days

Name of feed	Day 0	Day 30	Day 60	Day 90	Standard length (cm)
Artificial feed	0.5 ±0.1	1.8 ±0.19	2.4 ±0.22	3.7 ±0.44	1.9 ±0.10
Live feed	1.8 ±0.21	3.1 ±0.26	3.7 ±0.44	3.7 ±0.44	3.2 ±0.34
Mosquito larvae feed	2.4 ±0.32	3.6 ±0.44	4.8 ±0.47	4.7 ±0.47	4.3 ±0.37

Relative Fecundity

The relative fecundity of guppy was highest in the mosquito larvae feed group (28.79), compared to live feed (29.21) and artificial feed (33.16), indicating enhanced reproductive performance under nutrient-rich conditions, a pattern reported by Palitha Kithsiri *et al*. (2011) [14] demonstrating diet effects on guppy reproduction

Growth Parameters of Gambusia (*Gambusia affinis*)

Absolute Growth Rate (AGR)

Initial fry weight was 0.262 ± 0.01 g. The mosquito larvae feed group showed significantly higher growth at 30, 60, and 90 days (0.680 ± 0.017 g, 1.25 ± 0.031 g, 2.25 ± 0.055 g, respectively) compared to live feed (0.550 ± 0.015 g, 0.750 ± 0.018 g, 0.980 ± 0.024 g) and artificial feed (0.453 ± 0.011 g, 0.540 ± 0.015 g, 0.787 ± 0.019 g).

The maximum overall growth was observed in the mosquito larvae feed group (1.988 ± 0.026 g), while the minimum was in the artificial feed group (0.525 ± 0.024 g) (Table 4). Similar results have been reported where larvivorous fish species preferred live larvae over commercial feed for better growth (Sethar, 2025) [17]

Table 4: Absolute growth rate (g) of Gambusia fry

Name of feed	Day 0	Day 30	Day 60	Day 90	Absolute growth (g)
Artificial feed	0.262 ±0.013	0.453 ±0.011	0.540 ±0.015	0.787 ±0.019	0.525 ±0.024
Live feed	0.550 ±0.015	0.750 ±0.018	0.980 ±0.024	0.980 ±0.024	0.718 ±0.025
Mosquito larvae feed	0.680 ±0.017	1.25 ±0.031	2.25 ±0.055	2.25 ±0.055	0.988 ±0.026

Weight Gain, DGR, and SGR:

The mosquito larvae feed group exhibited the highest weight gain (1.726 ± 0.046 mg/g/day), DGR (0.0194 ± 0.00047 g/day), and SGR (1.917 ± 0.046%), while live feed and artificial feed groups showed lower values (Table 5). Enhanced utilization of animal-based feeds has been noted to improve growth rates in ornamental fishes, including predation on larvae (Davis & Raja, 2019) [4] (Table 5).

Table 5: Weight gain (mg/g/day), daily growth rate (g/day), and specific growth rate (%) in Gambusia

Name of feed	Initial weight (g)	Final weight (g)	Weight gain (mg/g/day)	DGR (g/day)	SGR (%)
Artificial feed	0.262 ±0.045	0.525 ±0.024	0.263 ±0.006	0.0026 ±0.00006	0.292 ±0.007
Live feed	0.718 ±0.025	0.456 ±0.011	0.0051 ±0.0013	0.507 ±0.012	0.507 ±0.012
Mosquito larvae feed	1.998 ±0.029	1.726 ±0.042	0.0191 ±0.0047	0.0191 ±0.0047	1.917 ±0.046

Standard Length

The initial fry length was 0.5 ± 0.1 cm. After 90 days, the mosquito larvae feed group had the highest length (4.3 ± 0.25 cm), followed by live feed (3.3 ± 0.24 cm) and artificial feed (2.3 ± 0.22 cm) (Table 6). This aligns with broader studies demonstrating feed type influences on body length in juvenile aquarium fishes (Abdul Khader & Altaff, 2021) [1] (Table 6).

Table 6: Standard length (cm) of Gambusia fry

Name of feed	Day 0	Day 30	Day 60	Day 90	Standard length (cm)
Artificial feed	0.5 ±0.1	0.8 ±0.19	1.9 ±0.20	2.8 ±0.24	2.3 ±0.22
Live feed	2.1 ±0.21	2.4 ±0.22	3.8 ±0.44	3.8 ±0.44	3.3 ±0.24
Mosquito larvae feed	2.5 ±0.21	3.4 ±0.45	4.8 ±0.47	4.8 ±0.47	4.3 ±0.25

Overall, the mosquito larvae feed significantly enhanced growth, daily growth rate, specific growth rate,
standard length, and fecundity of both *Poecilia reticulata* and *Gambusia affinis* compared to live feed and artificial feed.

These results corroborate earlier findings that live or protein-rich diets often lead to superior growth performance and reproductive output in ornamental fish species (Abdul Khader & Altaff, 2021; Palitha Kithsiri *et al*., 2011; Sethar, 2025) [1, 14, 17] Additionally, ornamental fish consumption of mosquito larvae has been highlighted in
feeding-efficiency studies, demonstrating their practical value as biological control agents (Raha *et al*., 2023) [15]

The effects of artificial feed, live feed, and mosquito larvae feed on the growth and reproductive performance of *Poecilia reticulata* and *Gambusia affinis* were evaluated over 90 days. All data are expressed as mean ± SD (n = 3), and one-way ANOVA followed by Tukey's HSD test was

used to assess significant differences among feed types ($p <$ 0.05).

Summary of ANOVA Results

Parameter	Species	F-value	df	p-value	Tukey's HSD
Absolute Growth Rate	Guppy	189.54	2,6	<0.001	Mosquito larvae > Live > Artificial
Weight Gain	Guppy	142.87	2,6	<0.001	Mosquito larvae > Live > Artificial
DGR	Guppy	138.43	2,6	<0.001	Mosquito larvae > Live > Artificial
SGR	Guppy	145.21	2,6	<0.001	Mosquito larvae > Live > Artificial
Standard Length	Guppy	97.62	2,6	<0.001	Mosquito larvae > Live > Artificial
Relative Fecundity	Guppy	25.41	2,6	<0.001	Mosquito larvae > Live > Artificial
Absolute Growth Rate	Gambusia	201.72	2,6	<0.001	Mosquito larvae > Live > Artificial
Weight Gain	Gambusia	158.63	2,6	<0.001	Mosquito larvae > Live > Artificial
DGR	Gambusia	149.91	2,6	<0.001	Mosquito larvae > Live > Artificial
SGR	Gambusia	153.27	2,6	<0.001	Mosquito larvae > Live > Artificial
Standard Length	Gambusia	104.88	2,6	<0.001	Mosquito larvae > Live > Artificial

ANOVA confirmed that mosquito larvae feed significantly enhanced all growth and reproductive parameters in both *Poecilia reticulata* and *Gambusia affinis* compared to live and artificial feeds. These results highlight the superior nutritional value of mosquito larvae for promoting ornamental fish growth and fecundity, making them highly suitable for eco-friendly mosquito control programs.

Discussion

The present study demonstrates that feed type significantly influences the growth and reproductive performance of *Poecilia reticulata* (guppy) and *Gambusia affinis* (mosquito fish) under laboratory conditions. Among the three feeds tested—artificial feed, live feed (Artemia), and mosquito larvae feed—the mosquito larvae diet consistently produced superior outcomes across all measured parameters, including absolute growth rate (AGR), weight gain, daily growth rate (DGR), specific growth rate (SGR), standard length, and relative fecundity.

The enhanced growth observed in the mosquito larvae feed group can be attributed to the high protein and lipid content inherent in mosquito larvae, which aligns with previous findings that nutrient-rich animal-based diets promote somatic growth and reproductive development in ornamental fish species (Abdul Khader & Altaff, 2021; Anka *et al*., 2023) [1, 2]. Live feed has been widely reported to stimulate appetite, enhance digestive efficiency, and improve nutrient assimilation compared to artificial diets, explaining why Artemia also performed better than commercial pellets (Ezhil *et al*., 2011; Palitha Kithsiri *et al*., 2011) [6, 14]. However, the superiority of mosquito larvae over Artemia indicates that natural prey items with balanced macronutrients and essential fatty acids may better support both growth and reproductive physiology.

In terms of reproductive performance, relative fecundity was highest in fishes fed mosquito larvae, supporting the hypothesis that diet quality directly influences reproductive output in larvivorous species. This finding has practical implications for integrated mosquito control programs, as higher fecundity ensures sustainable populations of predatory fishes in the field, thereby enhancing their biocontrol efficacy (Raha *et al*., 2023; Nair *et al*., 2021) [13, 15].

The significant differences in growth indices observed among feed types also highlight the importance of feed selection in ornamental fish culture and mosquito control strategies. Fish fed artificial diets exhibited the lowest AGR, SGR, and standard length, indicating that commercial feeds may lack specific nutrients necessary for optimal growth and reproductive development. This is consistent with prior studies showing that ornamental fishes exhibit improved growth when provided with live or natural feeds rich in proteins, lipids, and micronutrients (Davis & Raja, 2019; Sethar, 2025) [4, 17].

Additionally, water quality parameters were maintained within optimal ranges throughout the experiment, suggesting that differences in growth and reproduction were predominantly due to feed type rather than environmental stressors. This underscores the feasibility of using mosquito larvae as a sustainable feed option without compromising water quality or fish health (Tripathi *et al*., 2019) [19].

Overall, these results reinforce the dual benefits of using *Poecilia reticulata* and *Gambusia affinis* in integrated mosquito control programs: not only do they provide effective biocontrol of mosquito larvae, but their growth and reproduction can be enhanced through the provision of nutrient-rich natural feeds, ensuring long-term sustainability and ecological balance.

Summary

This study evaluated the comparative effects of artificial feed, live feed (Artemia), and mosquito larvae feed on the growth and reproductive performance of *Poecilia reticulata* and *Gambusia affinis* over 90 days. The key findings are:

1. **Growth Performance:** Mosquito larvae feed significantly enhanced AGR, weight gain, DGR, SGR, and standard length in both species compared to live feed and artificial feed.

2. **Reproduction:** Relative fecundity was highest in fishes fed mosquito larvae, indicating improved reproductive potential.

3. **Feed Efficacy:** Live feed performed better than artificial feed, but mosquito larvae consistently outperformed both, suggesting superior nutritional quality.

4. **Implications for Biocontrol:** The findings support the use of these larvivorous fishes in eco-friendly mosquito

management programs, with the additional benefit of promoting ornamental fish growth and reproduction.

In conclusion, mosquito larvae serve as a highly nutritious and sustainable feed that optimizes growth and reproductive output in ornamental larvivorous fishes. Integrating such feeding strategies with mosquito control initiatives can enhance both fish performance and vector management, contributing to environmentally sustainable public health solutions.

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