

## Impact of Different Live Feeds on the Reproductive Performance of Tricolor Angelfish *Pterophyllum scalare*

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### Abstract

Angelfish is a widely cultivated ornamental species valued for its distinctive morphology and vibrant coloration. Nevertheless, its culture is often constrained by suboptimal egg production and inconsistent larval quality. Enhancing broodstock performance through the use of nutrient-rich live feeds is a common strategy to accelerate gonadal maturation and improve spawning outcomes. This study evaluated the effects of four different live feeds on the reproductive success of tricolor angelfish. A completely randomized design (CRD) was used, comprising four treatments with three replicates each: Tubifex worms (CS), mosquito larvae (JN), Daphnia (KA), and bloodworms (CD). Mosquito larvae (JN) produced the highest reproductive metrics, including an egg count of  $573 \pm 5.03$  eggs, a fertilization rate (FR) of  $95.29 \pm 1.12\%$ , a survival rate (SR) of  $86.84 \pm 0.65\%$ , and the greatest economic return (IDR 79,332). These findings indicate that mosquito larvae represent the most effective and economically advantageous live feed for enhancing spawning performance and larval production in angelfish.

Keywords: angelfish, bloodworms, mosquito larvae, spawning.

### I. INTRODUCTION

Ornamental fish aquaculture in Indonesia is expanding rapidly, driven by rising domestic and international market demand. Among the most popular species is the tricolor angelfish (*Pterophyllum scalare*), favored for its unique morphology, striking coloration, and ease of rearing. However, angelfish production faces significant bottlenecks, particularly low fecundity and suboptimal larval quality (Laila *et al.*, 2022). A critical strategy to enhance egg production is the provision of high-nutrient diets to accelerate gonadal maturation and facilitate spawning. Purwoprayogo *et al.*, (2021) emphasize that such diets must contain a balanced profile of amino acids, fatty acids, carbohydrates, vitamins, and minerals.

Natural feeds were selected in this study due to

their nutritional relevance to gonadal maturation in fish. *Tubifex* sp. contains high protein (57–60%) and lipid (13–20%) levels (Setiadi *et al.*, 2023). Mosquito larvae also exhibit high protein content (>50% dry weight) (Christaki *et al.*, 2022). Bloodworms supply moderate to high protein (39.4–50.81%), low lipid levels (1.70–4.18%), and carbohydrates ranging from 22.94–25.76% (Soelistiyarto and Nyata, 2020). In contrast, Daphnia contains lower protein (4%) and lipid levels (0,54 %) (Simanjuntak *et al.*, 2021). These nutrients, particularly proteins and essential fatty acids, are critical for vitellogenin synthesis and yolk formation during vitellogenesis. Therefore, the selected natural feeds represent contrasting nutritional profiles for

evaluating their effectiveness in accelerating gonadal maturation and improving broodstock reproductive performance.

Previous studies have evaluated various live feeds to assess their effects on ornamental fish production. Septiyana *et al.*, (2023) reported that Tubifex worms effectively enhance the quality of molly fish offspring. Similarly, Satyani (2017) found that *Daphnia* sp. improves fecundity and larval yields in betta fish, while Setyadi (2022) demonstrated that mosquito larvae can significantly reduce mortality rates in molly larvae. Against this background, the present study investigates specific live feed sources capable of supporting enhanced angelfish production.

The objective of this study was to evaluate and identify the live feed types that most effectively optimize angelfish reproduction. Furthermore, these findings are intended to provide actionable insights for aquaculturists regarding natural feeds that positively influence the reproductive performance and financial sustainability of *P. scalare* culture.

## II. MATERIALS AND METHODS

### 2.1 Study Site and Duration

This applied research was conducted at Union Aquarium, Pondok Rajeg, Cibinong, Bogor Regency, West Java, Indonesia. The study was carried out over a 60-day period, from 1 December 2024 to 1 February 2025.

### 2.2 Experimental Materials and Equipment

The experimental setup consisted of aquaria measuring  $1 \times 0.5 \times 0.2 \text{ m}^3$ , siphon hoses, a 370 W (0.5 hp) blower (Resun), aeration tubing, biofoam, and PVC

Table 1 Live feed treatments for angelfish broodstock.

Treatment	Notes
CS	Feeding with Tubifex worms
JN	Feeding with mosquito larvae ( <i>Culex</i> sp.)
KA	Feeding with <i>Moina</i> sp.
CD	Feeding with bloodworms ( <i>Chironomus</i> sp.)

pipe substrates with a diameter of 7.5 cm. Broodstock consisted of tricolor angelfish (*Pterophyllum scalare*) sourced from a local breeder in Ciseeng, Bogor. The fish were 11–14 months old, with males averaging 12–14 cm in length and females 8–10 cm. Live feeds included mosquito larvae (*Culex* sp.) cultured on-site, *Moina* sp. obtained from nearby Setu Cikaret, and bloodworms (*Chironomus* sp.) and Tubifex worms purchased from local suppliers.

### 2.3 Experimental Design

A completely randomized design (CRD) was employed, comprising four treatments with three replicates. Each treatment consisted of a different type of live feed administered to the broodstock (Table 1).

### 2.4 Broodstock Management and Spawning

Aquaria ( $1 \times 0.5 \times 0.2 \text{ m}$ ) were cleaned and filled with dechlorinated water to a depth of 20 cm. Broodstock were selected based on gonadal maturity, assessed through morphological and behavioral traits. Males exhibited slightly protruding foreheads, slender abdomens, brighter coloration, and larger body sizes, whereas females were smaller, with rounded abdomens and duller coloration. Mature males displayed chasing and aggressive behaviour, while females exhibited enlarged abdomens and slightly protruding, reddish urogenital pores, indicating readiness for spawning

Table 2. Formulas used to calculate reproductive performance parameters of *Pterophyllum scalare* broodstock.

Parameter	Formula	Reference
Spawning Frequency (F)	$F = \frac{\text{Number of spawnings}}{\text{Time period}}$	Lagler <i>et al.</i> , 1997
Fecundity	Total eggs per female per spawning	Abdulkarim <i>et al.</i> , 2019
Fertilization Rate (FR, %)	$FR(\%) = \frac{\text{Fertilized eggs}}{\text{Total egg}} \times 100$	Fani <i>et al.</i> , 2018; Hui <i>et al.</i> , 2014
Hatching Rate (HR, %)	$HR(\%) = \frac{\text{Hatched larvae}}{\text{Fertilized eggs}} \times 100$	Marsela <i>et al.</i> , 2018; Hui <i>et al.</i> , 2014
Absolute Length Growth ( $\Delta L$ )	$\Delta L = \text{final length} - \text{initial length}$	Mulqan, 2017
Survival Rate (SR, %)	$SR(\%) = \frac{\text{Surviving larvae}}{\text{Initial larvae}} \times 100$	Widyatmoko <i>et al.</i> , 2019

(Chaco *et al.*, 2006; Degani *et al.*, 1997; Saputra, 2020).

Fish were stocked at 1 fish/L and fed their assigned live feed, mosquito larvae (*Culex* sp.), *Moina* sp., Tubifex worms, or bloodworms (*Chironomus* sp.) twice daily to satiation (Situmorang *et al.*, 2023). Water quality was maintained through daily 20% water replacement and regular biofoam cleaning. Methylene blue was applied at a concentration of 0.05 mL L<sup>-1</sup> to prevent fungal growth. Temperature, pH, and total dissolved solids (TDS) were measured in situ, while ammonia and hardness were analyzed weekly ex situ at the Water Quality Laboratory, Study Program of Fish Breeding Technology and Management, IPB University.

Spawning was conducted at a 1:1 male-to-female ratio using PVC pipe substrates. Females attached eggs to the substrate, which were subsequently fertilized by males (Purwoprayogo, 2021). Eggs were harvested daily at 16:00 WIB, counted, and incubated in 19 L containers containing 0.05 mL/L methylene blue. Unfertilized eggs were removed, and hatching was monitored daily. Fertilized eggs appeared transparent, whereas unfertilized eggs were opaque and milky (Mustahal *et al.*, 2014). Larvae were stocked at 3 fish/L starting on day 7 post-hatch and fed *Artemia* until day 30, when they reached juvenile size (Purwoprayogo, 2021).

### 2.5 Reproductive Performance

Reproductive performance was evaluated based on fecundity, fertilization rate (FR), hatching rate (HR), absolute length growth (PPM), survival rate (SR), and spawning frequency (Table 2). Fecundity was defined as the total number of eggs produced per female per spawning event and was estimated from substrate photographs to avoid damaging the samples (Abdulkarim *et al.*, 2019). FR and HR were calculated as the percentages of fertilized and hatched eggs, respectively (Fani *et al.*, 2018; Marsela *et al.*, 2018; Hui *et al.*, 2014). PPM was defined as the difference between final and initial total length (Mulqan, 2017), while SR was defined as the proportion of larvae surviving until the end of the experimental period (Widyatmoko *et al.*, 2019). Spawning frequency was recorded as the number of spawning events per unit time (Lagler *et al.*, 1997).

### 2.6 Net revenue (Economic Analysis)

Net revenue ( $\pi$ ) was calculated by comparing the cost of each feed treatment with the market value of

larvae (Yunita, 2017).

$$\pi = TR - TC$$

where  $\pi$  = net revenue (Rp), TR = total revenue (Rp), and TC = total cost (Rp) (Yunita, 2017).

### 2.7 Water Quality Monitoring

Water quality parameters monitored during the study included temperature, pH, ammonia, hardness, and total dissolved solids (TDS). Temperature and pH were measured twice daily (08:00–09:00 and 16:00–17:00), while TDS was recorded once daily in the afternoon using a digital pH meter and thermometer in situ. Ammonia and hardness were analyzed ex situ once a week throughout the rearing period using a spectrophotometer at the Water Quality Laboratory, Study Program of Fish Hatchery Technology and Management, School of Vocational Studies, IPB University.

### 2.8 Data Analysis

Data were tabulated using Microsoft Excel 2019 and analyzed using one-way ANOVA in SPSS version 25 at 95% confidence level. Significant differences among treatments were determined using Duncan's multiple range test. Water quality data were analyzed descriptively.

## III. RESULT

### 3.1 Reproductive performance

The type of natural feed significantly influenced the reproductive performance of *Pterophyllum scalare* broodstock (Duncan's test,  $p < 0.05$ ). The highest spawning frequency was observed in the CD treatment group, with 4 spawning events over 30-day period,

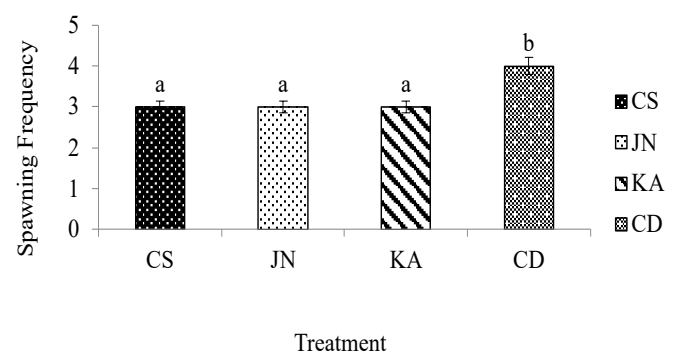


Figure 1. Spawning frequency of *P. scalare* fed different live feeds (CS: tubifex; JN: mosquito larvae; KA: water fleas; CD: bloodworms).

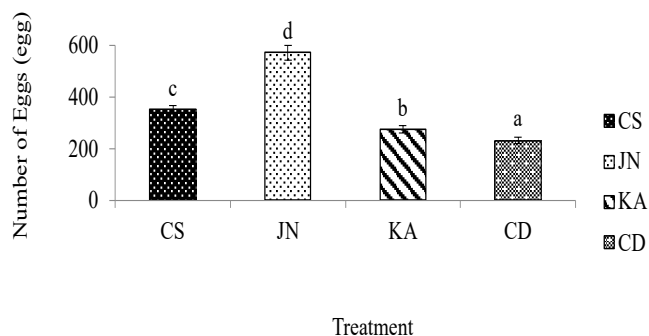


Figure 2. Fecundity of *P. scalare* broodstock under different live feed treatments, (CS: tubifex; JN: mosquito larvae; KA: water fleas; CD: bloodworms).

while broodstock in the KA, JN, and CS treatments spawned 3 times each (Figure 1).

Fecundity varied significantly among treatments. Broodstock fed JN produced the highest egg count (573 ± 5.03 eggs), followed by CS (351 ± 9.50 eggs), KA (274 ± 11.50 eggs), and CD (231 ± 10.01 eggs) (Figure 2). Fertilization rate (FR) was also highest in JN (95.29 ± 1.12%), with lower rates in CS (87.47 ± 3.47%), CD (85.41 ± 1.28%), and KA (81.74 ± 1.27%) (Figure 3).

Hatching rate (HR) did not differ significantly among treatments ( $p > 0.05$ ), ranging from 78.67 ± 4.94% (KA) to 85.59 ± 2.08% (JN) (Figure 4). Larval absolute growth (PPM) was similar across treatments, with values of 0.39–0.42 cm, and JN showing slightly higher growth (0.42 ± 0.01 cm) (Figure 5). Survival rate (SR) differed significantly, with larvae from JN treatment exhibiting the highest survival (86.84 ± 0.65%), followed by KA (85.37 ± 1.81%), CD (82.68 ± 2.49%), and CS (82.09 ± 1.29%) (Figure 6).

### 3.2 Economic analysis

Economic analysis revealed that feed type strongly affected larval productivity and profitability. The JN treatment generated the highest larval yield (366 larvae) and net revenue (Rp79,332), followed by

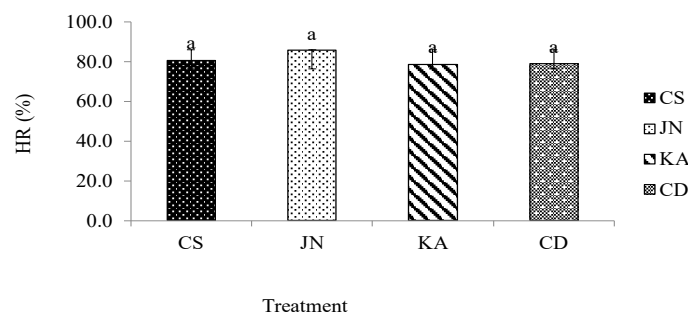


Figure 4. Hatching rate (%) of *P. scalare* under different live feed treatments, (CS: tubifex; JN: mosquito larvae; KA: water fleas; CD: bloodworms).

KA (net revenue Rp45,976) and CS (Rp42,274). The CD treatment yielded the lowest number of larvae (140) and net revenue (Rp18,284) (Table 3).

### 3.3 Water quality

Water quality parameters remained within acceptable ranges for *P. scalare* culture. During broodstock maintenance, temperature ranged 26.1–28.9°C, pH 8.1–8.9, TDS 106–274 mg/L, ammonia 0.025–0.200 mg/L, and hardness 108–131 mg/L as shown in Table 4. During egg incubation, temperature was 26.4–28.5°C and pH 6.8–7.7, while larval rearing recorded temperature 26.3–28.6°C and pH 8.0–9.1 as shown in Table 5. These values indicate that all treatments were maintained under suitable conditions without compromising reproduction or larval survival.

## IV. DISCUSSION

Spawning frequency of angelfish (*Pterophyllum scalare*) was highest in the bloodworm (CD) treatment, indicating that this diet effectively stimulates reproductive activity. Reproductive performance in angelfish is strongly influenced by both environmental conditions and appropriate feed, which can accelerate

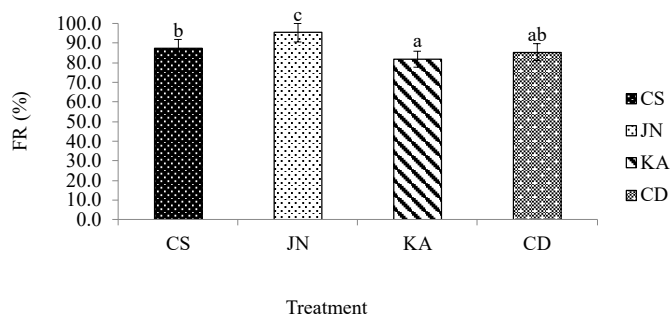


Figure 3. Fertilization rate (%) of *P. scalare* under different live feed treatments, (CS: tubifex; JN: mosquito larvae; KA: water fleas; CD: bloodworms).

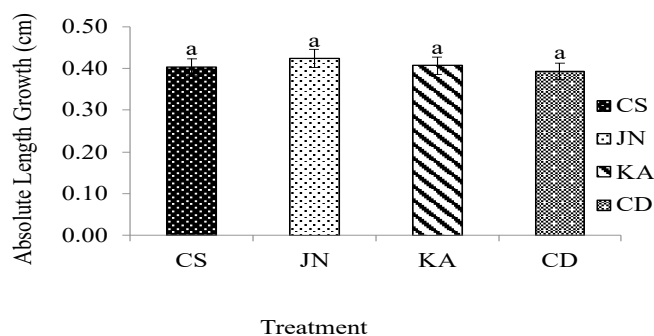


Figure 5. Absolute length growth (PPM, cm) of *P. scalare* larvae from broodstock fed different live feeds, (CS: tubifex; JN: mosquito larvae; KA: water fleas; CD: bloodworms).

Table 3. Larval productivity and economic analysis of *P. scalare* broodstock fed different live feeds.

Treatment	Larvae Number (ind.)	Mean Larval Length (cm)	Price (Rp/ind.)	Revenue (Rp)	Rearing Cost (Rp)	Feed Cost (Rp)	Net Profit (Rp)
CS	228	0.90	270	61,560	9,286	10,000	42,274
JN	366	0.91	274	100,284	9,286	11,666	79,332
KA	251	0.89	267	66,928	9,286	11,666	45,976
CD	140	0.90	269	37,570	9,286	10,000	18,284

gonadal maturation and spawning (Ortega-Salas *et al.*, 2009). In this study, water quality parameters, including temperature, pH, ammonia, and hardness were maintained within optimal ranges, ensuring a conducive environment for reproduction. Bloodworms, with high protein (62.5%) and lipid (11.6%) content, likely contributed to faster gonadal development, consistent with findings in other species such as *Corydoras panda* and Red Lizard (Fallah, 2020).

Fecundity was highest in the mosquito larvae (JN) treatment, suggesting that this feed supports gonad development and egg production most effectively. Previous studies similarly reported that mosquito larvae maximize offspring yield in ornamental fish (Rahadian *et al.*, 2015). Fertilization rates (FR) also varied significantly across treatments, demonstrating the importance of feed type in reproductive success. Optimal water conditions, such as stable pH, low ammonia, and appropriate temperature further enhanced fertilization outcomes (Kumar *et al.*, 2020; Harisman *et al.*, 2021; Putra *et al.*, 2020; Hidayat *et al.*, 2018).

Hatching success (HR) was less affected by feed and more dependent on incubation conditions, which are critical for embryo development (Migaud *et al.*, 2013). In this study, incubation temperature (26.4–28.5°C) and pH (6.8–7.7) remained within optimal ranges (24–30°C; pH 6.5–7.5, SNI 7870-

2023), aligning with previous reports that water quality significantly influences egg hatching in ornamental fish (Swain, 2006; Ortega-Salas *et al.*, 2009).

Post-hatch larval growth was primarily influenced by the type of feed provided after hatching rather than the broodstock diet. Artemia, provided from day 7 onward, supported consistent larval growth across all treatments, consistent with Damayanti *et al.*, (2019), who observed no significant differences in larval growth with alternative feeds.

Larval survival rate (SR) was highest in the JN treatment, likely due to the high protein content (50–60% dry weight) of mosquito larvae, which supports gonadal maturation, egg quality, embryo development, and larval viability (Dutta *et al.*, 2015; Abdulkarim *et al.*, 2019). Mosquito larvae are easily digestible and stimulate broodstock appetite, further improving physiological condition and reproductive output.

Economically, mosquito larvae (JN) proved the most profitable natural feed. They generated the highest larval yield at the lowest cost, resulting in superior net revenue compared to other feeds. Bloodworms (CD), while stimulating spawning frequency, produced fewer larvae and incurred higher feed costs, thereby reducing profitability. This findings aligns with previous studies that feed type not only reproductive performance but also determines economic efficiency in ornamental fish

Table 4. Water quality parameters during broodstock rearing.

No	Parameters	Result	Standard	Unit
1	Temperature	26,1–28,9	24–30a	(°C)
2	pH	8,1–8,9	7–8,4b	-
3	Total Dissolve Solid (TDS)	106–274	100–1000c	(mg/L)
4	Ammonia	0,025–0,200	>0,5d	(mg/L)
5	Hardness	108–131	107–150a	(mg/L)

a: SNI 7870-2023, b: Dwiputra *et al.*, 2021, c: Raharjo *et al.*, 2016, d: Kocer and Sevgili 2014

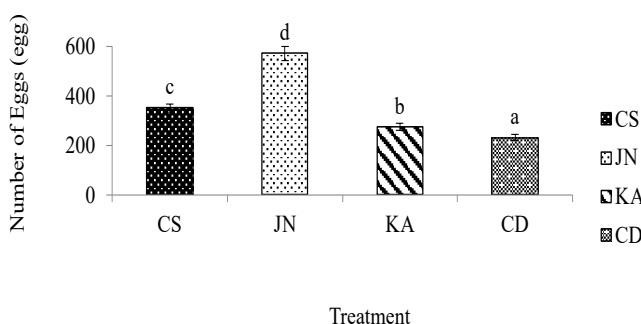


Figure 6. Survival rate (%) of *P. scalare* larvae from broodstock fed different live feeds, (CS: tubifex; JN: mosquito larvae; KA: water fleas; CD: bloodworms).

Table 5. Water quality during egg incubation and larval rearing of *P. scalare*.

Rearing Stage	Temperature (°C)	pH
Egg incubation	26,4–28,5	6,8–7,7
Egg incubation	26,3–28,6	8–8,9
Standar	24–30 a	7–8,4 b

a: SNI 7870-2023, b: Dwiputra *et al.*, 2021

culture (Sulaeman *et al.*, 2023). Therefore, mosquito larvae represent an effective and cost-efficient feed strategy, maximizing both biological and financial outcomes.

## V. CONCLUSION

Feeding mosquito larvae to angelfish (*Pterophyllum scalare*) significantly enhanced reproductive performance, resulting in the highest fecundity, fertilization rate, larval survival, and net economic return. These results indicate that mosquito larvae are an effective and cost-efficient feed for maximizing reproductive success and larval production in ornamental fish aquaculture. Future studies should explore combinations of natural feeds and extend observations to the seedling stage to fully evaluate long-term performance.

## CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in the manuscript.

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