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Nutritional Enrichment of *Daphnia* sp. and its Effect on the Growth of the Ranchu Goldfish *Carassius auratus*

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Abstract

Ranchu goldfish *Carassius auratus* is a premium ornamental fish commodity with high economic value; however, its growth tends to be slow, particularly during the fry stage. One strategy to address this issue is to enhance the quality of natural feed through nutritional enrichment. This study aimed to determine the effect of enriching *Daphnia* sp. with Dancow milk powder on the growth of Ranchu goldfish fry. The study employed a Completely Randomized Design (CRD) with three treatments: a control (no enrichment), enrichment at 0.6 g/L (Treatment A), and enrichment at 1.2 g/L (Treatment B), each with three replicates. The observed parameters included absolute length growth, absolute weight growth, specific length growth rate, feed efficiency (FE), survival rate, proximate analysis, and business analysis. The results showed that Treatment A (0.6 g/L enrichment) yielded the best results regarding length growth (6.81 ± 0.01 cm), weight growth (2.30 ± 0.01 g), and feed efficiency (43.53 ± 6.00%). Nutritional enrichment of *Daphnia* sp. at the appropriate dosage proved effective in improving the growth performance of Ranchu goldfish fry.
Keywords: *Daphnia* sp.; Ranchu goldfish; feed enrichment; Dancow milk

I. INTRODUCTION

The Ranchu goldfish is a type of ornamental fish popular in both local and international markets due to its unique body shape and diverse coloration (Fathimah et al., 2022; Windarto *et al*., 2013). West Java serves as a major production hub, experiencing a 78% increase in production between 2019 and 2020 (Ministry of Marine Affairs and Fisheries, 2020). A common issue is the fish's relatively slow growth rate, particularly during the larval to fry stages *Daphnia* sp. as a highly nutritious natural feed with a protein content of 42–54% and fat content of 6.5–8% (Herawati *et al.*, 2015); however, the protein content is insufficient to meet the 57% protein requirement of Ranchu goldfish. Enriching *Daphnia* sp. with milk powder, which contains protein, vitamins, and essential fatty acids such as EPA and DHA, is expected to enhance its nutritional value. This study aims to examine the effect of enriching *Daphnia* sp. with milk powder on the growth of Ranchu goldfish fry.

II. MATERIALS AND METHODS

The research was conducted from February 24 to April 9, 2025, at the Sukabumi Fish Seed Center, located on Jalan Cijambe, Sukakarya Urban Village, Warudoyong District, Sukabumi City, West Java. The study employed a Completely Randomized Design (CRD) with three treatments and three replicates. The research design is presented in Table 1.

The parameters tested included absolute length growth known as Pertumbuhan Panjang Mutlak (PPM), absolute weight growth known as Pertumbuhan Bobot

Table 1 Experimental design for the enrichment of *Daphnia* sp. using commercial milk powder.

Treatment	Description
Control	*Daphnia* sp. without milk supplementation
A	Additional milk at a dosage of 0,6 g/L
B	Additional milk at a dosage of 1,2 g/L

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Mutlak (PBM), specific length growth rate known as Laju Pertumbuhan Panjang Spesifik (LPPS), feed efficiency known as Efisiensi Pemberian Pakan (EPP), survival rate, proximate analysis, and business analysis.

The calculation of absolute length growth was performed based on the formula proposed by Effendie (1997):

PPM= Lt – Lo

where Lt = Average length of fish at the end of the rearing period (cm),

Lo = Average length at the beginning of the rearing period (cm).

Absolute weight growth was calculated using the formula proposed by Effendie (1997):

PBM = Wt - Wo

where Wt = Average biomass at the end of the maintenance period.

Wo = Average biomass at the beginning of the rearing period

The LPPS parameter serves as a quantitative indicator for assessing fish growth rate during a specific rearing period. The LPPS value is determined through a calculation based on a formula adapted from Abadi (2018):

LPPS= (Lt – Lo/t) ×100

where Lt is the average length of fish at the end of the rearing period (cm),

Lo = average length at the beginning of the rearing period (cm),

t = rearing duration (days)

Feed Efficiency (FE) was calculated to assess the effectiveness of the feed in supporting fish biomass growth during the rearing period. According to Arief (2014), FE values can be determined using the following equation:

EPP = (Bt – Bo + Bd)/F ×100

where Bd is the total weight of dead fish (g).

Bt = final fish biomass weight (g);

Bo = initial fish biomass weight (g);

F = total feed administered

The survival rate is calculated at the end of the rearing period; this calculation yields the percentage of fish that survived throughout the trial. According to Effendie (1997), the survival rate is calculated using the following formula:

Survival rate = (Nt/No) ×100

Nt = total number of fish at the end of the rearing period;

No = total number of fish at the beginning of the rearing period.

Proximate analysis, also known as chemical analysis, is a procedure for evaluating the nutrient composition of fish feed by measuring specific parameters. The components analyzed include moisture, ash, protein, fat, and carbohydrate content, as well as an estimate of energy value. All testing is conducted at the laboratory facilities of PT Saraswati Indo Genetech (SIG).

The business analysis parameters for each test treatment include total cost, number of cycles, revenue, profit, R/C ratio, break even point (BEP) in units and in monetary value (rupiah), cost of production (HPP), and payback period (PP).

- Fecundity was determined by direct counting of all eggs produced during each spawning event and expressed as the total number of eggs per spawning
- FR (%)= (Number of fertilized eggs)/(Number of eggs sampled) x100% (Prama *et al.,* 2014).

III. RESULT AND DISCUSSION

3.1 Absolute Length Growth and Absolute Weight Growth

Broodstock The results for absolute length growth (PPM) showed a statistically significant difference ($P<0.05$) between treatment A and the other treatments. Treatment A yielded the highest PPM value (6.81 ± 0.01 cm), whereas the lowest value was recorded for Treatment K (2.90 ± 0.04 cm). These data indicate that the absence of a specific treatment tends to result in a lower absolute length growth. The data on absolute length growth are shown in Figure 1.

Figure 1 Absolute Length Growth (PPM) of Ranchu goldfish (*Carassius auratus*) fry. Different superscript letters indicate significant differences

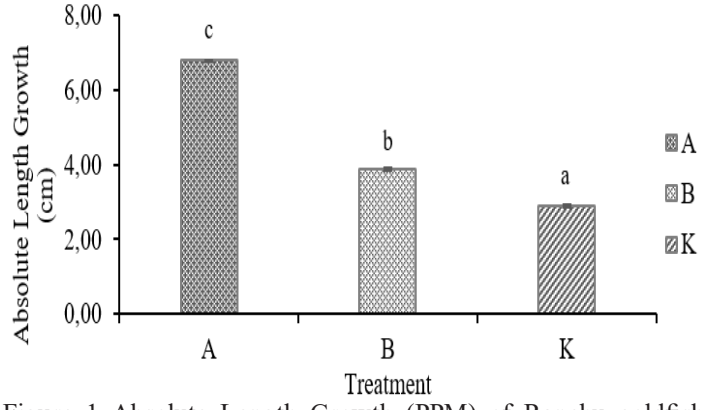


Figure 1 Absolute Length Growth (PPM) of Ranchu goldfish (*Carassius auratus*) fry

(P<0.05) among treatments.

Data on absolute weight growth (PBM) indicated a significant difference (P<0.05) between treatments A and B and K. The highest weight gain was recorded for treatment A, with a value of 2.30±0.01 g. Treatment B showed a value of 1.58±0.02 g, whereas the lowest absolute weight growth was observed in treatment K (1.27±0.02 g). The data on absolute weight gain are presented in Figure 2.

Figure 2. Absolute weight gain (AWG) of Ranchu goldfish (*Carassius auratus*) fry. Different superscript letters indicate significant differences (P<0.05) among treatments.

Nutritional enrichment of feed using commercial milk has been shown to influence the growth performance of Ranchu goldfish fry. Feeds with high nutritional content—specifically protein, essential amino acids, and fatty acids—play a crucial role in supporting fish growth (NRC, 1993). *Daphnia* sp. contains protein, unsaturated fatty acids, and carotenoids; these are vital nutrients that can be utilized to support the growth of fish fry (Nandlal & Pickering, 2004). Enriching live feed *Daphnia* sp. by adding commercial milk at a dosage of 0.6 g/L yielded a more optimal growth response than other treatments. According to Widanarni *et al.*, (2017), Dancow milk contains nutrients, including protein, fat, vitamins, and essential minerals such as calcium and phosphorus, which are vital for body tissue formation and metabolic processes. The nutritional content of feed plays a key role in determining the efficiency of metabolic processes and growth rate of cultured fish. Research conducted by Jusadi *et al.*, (2008) demonstrated that enriching *Daphnia* sp. can increase the vitamin levels within the organism's body.

A significant increase in the weight and length of Ranchu goldfish fry was observed at 0.6 g/L, which was attributed to the more complete availability of essential nutrients and optimal digestibility for the fish. The high protein content in enriched *Daphnia* sp. is believed to accelerate the formation of body tissues particularly muscle while simultaneously increasing the fish's body mass. This underscores the role of protein as a primary structural component in muscle tissue formation, making its presence a key determinant in accelerating the growth rate of aquatic organisms. This finding is supported by research conducted by Mokoginta *et al.,* (2003), which demonstrated that fish larvae fed with lipid-enriched *Daphnia* sp. exhibited greater relative weight gain compared to those fed unenriched *Daphnia* sp. Furthermore, this feed enrichment strategy resulted in the highest larval survival rates among the tested treatments. Nutrient enrichment strategies specifically increasing protein and fatty acid levels represent an effective and practical approach to optimizing the growth performance of cultured fish, particularly during the early life stages or the fry phase, when access to high-quality nutrition is critical.

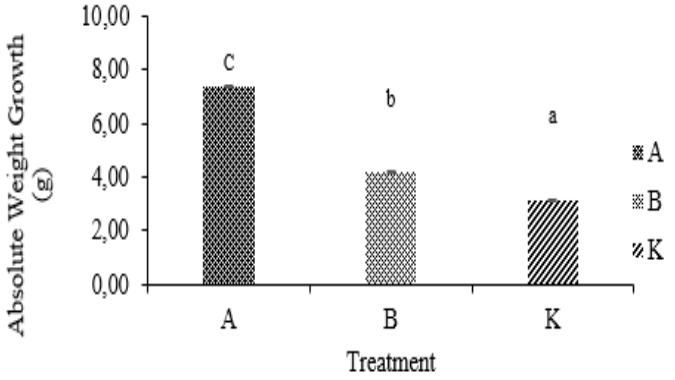


Figure 2. Absolute weight gain (AWG) of Ranchu goldfish (*Carassius auratus*) fry.

3.2 Specific Length Growth Rate (SLGR)

Calculations of the SGR-L (Specific Growth Rate in Length) values revealed a significant difference (P<0.05) for treatment A, with a mean value of 1.86±0.01%. Treatment K exhibited the lowest SGR-L value at 1.0±0.02%, indicating that the type of treatment influenced the specific growth rate in length of Ranchu goldfish fry. The SGR-L data are presented in Figure 3.

Figure 3. Specific Length Growth Rate (SLGR) of Ranchu goldfish (*Carassius auratus*) fry. Different superscript letters indicate significant differences (P<0.05) among treatments.

The effectiveness of the nutritional enrichment process was reflected in the higher specific length growth rate (SLGR) observed in treatment A. The more comprehensive nutritional profile of the enriched *Daphnia* sp. feed supports accelerated metabolic processes and growth, particularly during the early life stages, when fish require optimal nutrition for body structure development. According to Halver & Hardy (2002), feed quality, specifically protein and energy content, is a critical determinant of fish growth. Similar findings were reported by Sari *et al.*, (2015), who stated that enriched natural feed significantly enhances the specific growth rate because it is more easily digested and absorbed by fish than non-enriched feed.

3.3 Feed Conversion Efficiency (FCE)

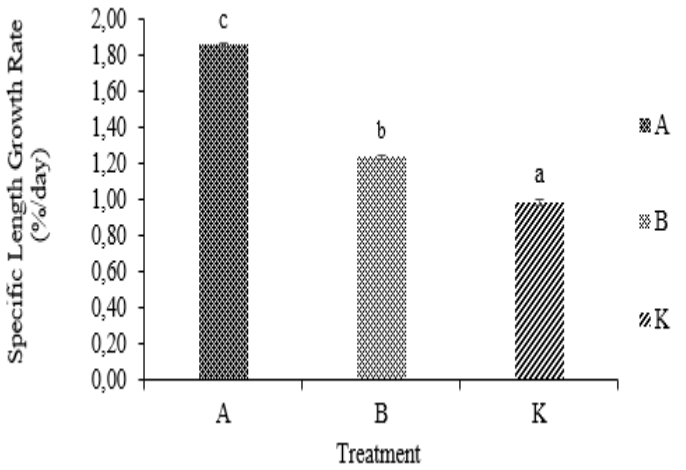


Figure 3. Specific Length Growth Rate (SLGR) of Ranchu goldfish (*Carassius auratus*) fry

Feed efficiency (FE) across the treatments showed no statistically significant differences (P>0.05), although a trend of improvement was observed. Treatment A yielded the highest FE value at 43.53±6.00%, followed by Treatment B at 33.81±1.65%, whereas the control treatment recorded the lowest value at 17.42±12.74%. These data indicate that Treatment A was the most effective in enhancing feed efficiency compared to Treatments B and the control. A visualization comparing feed efficiency is presented in Figure 4.

The Different superscript letters indicate significant differences (P<0.05) among treatments.

Feed utilization efficiency (FUE) did not differ significantly among the treatments. The highest value was observed in treatment A, indicating that the feed was optimally utilized by the fish. This efficiency is linked to the availability of nutrients that are easily absorbed and support plant growth (Munisa *et al.*, 2015). Treatment B showed lower efficiency than treatment A but still outperformed the control, indicating a positive effect, albeit suboptimal. The lowest FUE value in the control group reflects the limited effectiveness of the feed, without additional treatments, in supporting growth (Tacon & Metian, 2008). The superior performance in treatment A reinforces the finding that appropriate treatments can enhance feed efficiency and support successful aquaculture (Craig *et al.*, 2017).

3.4 Survival

The analysis results indicated that the highest survival rate was observed in treatment B, with a value of 100.00 ± 0.00%. The survival rate for treatment A reached 95.56 ± 7.70%, which was slightly lower than that of treatment B, but still reflected a high survival rate. Treatment C exhibited the lowest survival rate at 93.33 ± 12.75%. The differences between the treatments were not statistically significant (P > 0.05). The survival rates are illustrated in Figure 5.

Figure 5. Absolute Length Growth (ALG) of Ranchu goldfish (*Carassius auratus*) fry. Different superscript letters indicate significant differences (P<0.05) among treatments.

Optimal rearing conditions not only influenced growth but also reflected high survival rates across all treatment groups. A successful rearing system relies on a suitable environment and adequate feed availability. Boyd (2015) identified water quality and culture management as key factors in ensuring fish survival. Nutrition plays a crucial role in maintaining survival, particularly during the larval and fry stages when fish

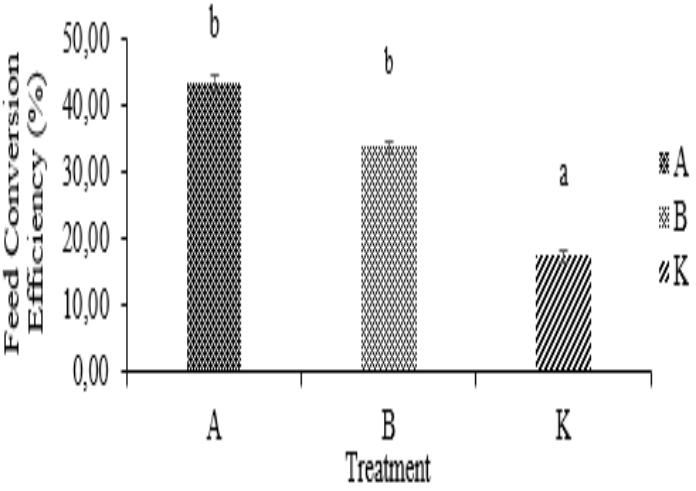


Figure 4. Feed Efficiency (FE) of Ranchu goldfish (Carassius auratus).

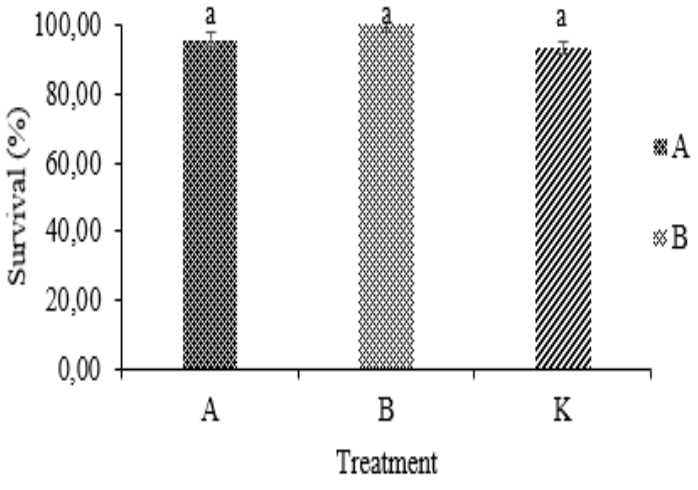


Figure 5. Absolute Length Growth (ALG) of Ranchu goldfish (*Carassius auratus*) fry.

are highly susceptible to stress and disease. According to De Silva and Anderson (1994), the availability of feed with a balanced nutrient composition is vital for supporting immune system function and enhancing fish resilience against various stressors. These conditions contribute to reducing potential mortality during the rearing period. This view is supported by the NRC (1993), which noted that a deficiency of essential nutrients in the diet can lead to reduced survival rates and suboptimal growth.

3.5 Proximate Analysis

Proximate analysis was conducted to determine the nutritional content of feed formulated by enriching the natural food organism, *Daphnia* sp., with commercial milk. Based on the analysis results, the feeds in treatments A and B exhibited nutritional compositions that were generally similar, despite some differences. The results of the proximate analysis are shown in Table 2.

Proximate analysis revealed differences in the nutritional content of *Daphnia* sp. enriched with Dancow milk between treatments A and B. Treatment A exhibited higher ash and protein levels (77.99% and 48.68%), whereas treatment B showed higher fat content and energy derived from fat (22.85% and 251.83 kcal). Moisture content was higher in treatment A, whereas carbohydrate content was greater in treatment B. These differences indicate that enrichment using Dancow milk can enhance the nutritional value of daphnia.

3.6 Business Analysis

The analysis of the natural feed enrichment venture for Ranchu goldfish fry (Treatment A) indicates total operational costs of IDR 57,907,316 and an initial investment capital of IDR 61,864,000. The venture generates an annual revenue of IDR 81,000,000 with a net profit of IDR 23,092,684, a break-even point of 1,056 units (valued at IDR 43,177,390), an R/C ratio of 1.4, and a payback period of 2.68 years. Based on these indicators, the venture is deemed financially feasible and potentially profitable. The analysis results are presented in Table 3.

Table 2 Proximate analysis results of enriching the natural feed *Daphnia* sp. with milk

Parameter	Treatment	
	A	B
Ash content (%)	77.99	19.72
Energy from fat (kcal)	228.57	251.83
Total fat content (%)	25.40	27.98
Moisture content (%)	98.11	97.82
Total energy (kcal)	455.03	461,01
Carbohydrate (%)	7.94	4.59
Protein (%)	48.68	47.71

A business analysis of the operation under Treatment A reveals that total expenditures during the production period amounted to IDR57,907,316. These costs comprised fixed costs of IDR43,213,135 and variable costs of IDR14,694,181. The initial investment required to launch the business was recorded at IDR61,864,000. The calculated cost of goods sold (COGS) was IDR35,745 per unit. With a selling price of IDR50,000 per unit, the business generated total annual revenue of IDR81,000,000. The difference between total revenue and total costs resulted in an annual net profit of IDR23,092,684.

Further analysis of business feasibility parameters indicates a break-even point (BEP) at a production volume of 1,056 units, equivalent to sales revenue of IDR43,177,390. The revenue-to-cost (R/C) ratio was 1.4, demonstrating that every IDR1 of expenditure generated IDR1.40 in revenue. This indicates that the business is financially viable and profitable. The payback period was calculated to be 2.68 years, meaning that the initial capital can be recouped in less than three years. Based on these indicators, the business under Treatment A shows promising prospects for development and a high potential for economic sustainability.

Providing natural feed in the form of *Daphnia* sp. enriched with nutrients, such as microalgae, vitamins, or animal protein, has been proven to significantly enhance fish growth performance and survival rates.

Table 3. Business Analysis of Nutritonal Enrichment *Daphnia* sp.

Parameter	Treatment A
Investment cost (IDR)	61,864,000
Fixed cost (IDR)	43,213,135
Variable cost (IDR)	14,694,181
Total cost (IDR)	57,907,316
Production cost per unit (IDR)	35,745
Selling price (IDR)	50,000
Total revenue/year (IDR)	81,000,000
Profit/year (IDR)	23,092,684
Variable cost/unit	9,070
Break even point (Units)	1,056
Break even point (IDR)	43,177,390
R/C ratio	1.4
Payback period (Years)	2.68

This strategy of utilizing natural feed not only positively impacts fish biological parameters but also offers the potential for greater economic returns compared to the use of conventional feed (Rachmawati *et al.*, 2018). The implementation of this natural feed enrichment method aligns with the technical guidelines issued by the Ministry of Marine Affairs and Fisheries (KKP), which emphasize the importance of adopting high-nutrient feed technologies to optimize aquaculture efficiency, particularly for high-value ornamental fish species (KKP 2022).

IV. CONCLUSION

Feeding *Daphnia* sp. enriched with Dancow milk at a dosage of 0.6 g/L (Treatment A) yielded the most optimal performance, characterized by an average length of 6.81 cm, weight of 2.30 g, and feed efficiency of 43.53% in Ranchu goldfish fry. This enrichment process contributes to increased levels of essential nutrients, particularly proteins, fatty acids, and vitamins, thereby supporting metabolic activity and maximizing fish growth. Survival rates across all treatments were high, indicating effective implementation of the rearing system. The business analysis results demonstrated satisfactory profitability and positive development prospects, with an R/C ratio of 1.4.

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