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The Editor-in-Chief of Indonesian Aquaculture Journal (IAJ) would like to thank reviewers who have voluntarily participated in reviewing the articles published in this journal. Their participation has ensured the on-time publication of IAJ volumes. The reviewers who participated in the publication of IAJ Volume 17 Number 2, December 2022 are as follows:

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PREFACE

Indonesian Aquaculture Journal (IAJ) has published high-quality research articles for 17 years and the current 2022 edition is IAJ Volume 17. The IAJ 2022 volumes are funded by the Agency for Marine and Fisheries Research and Human Resources in the fiscal year of 2022. All published articles have gone through a complete cycle of the evaluation process by the Editorial Board, Reviewers, and Editorial Office.

Since 2016, the IAJ has made a significant improvement in managing and evaluating publication through the online Open Journal Systems (OJS). Some minor changes were introduced in IAJ including:

1. A written description of p-ISSN and e-ISSN at the bottom of the cover skin page, title page, and table of contents
2. Additional sheets for the list of reviewers, focus & scope of IAJ and Indexing Information
3. A recognition sheet dedicated for reviewers involved in manuscript reviews of each issue
4. Each title sheet contains additional information regarding the website and email addresses as well a short description about IAJ.

These changes are described in the preface texts of each issue.

The Volume 17 Number 2, 2022 presents nine research articles: Genetic parameters of field survival in striped catfish (*Pangasianodon hypophthalmus*); Evaluation of resistance and gene expression of barramundi, *Lates calcarifer* post-infection of nervous necrosis virus; Isolation and identification of partial growth hormone (GH) mRNA of tiger shovelnose catfish *Pseudoplatystoma fasciatum* (Linnaeus, 1766); Reproductive performance of intraspecific hybrids of blue swimming crab (*Portunus pelagicus*); Comparison of production performance of striped catfish larvae (*Pangasianodon hypophthalmus*, Sauvage 1878) fed with live and frozen daphnia (*Daphnia magna*); Effects of microalgae spirulina *Arthrospira platensis* supplementation to the plant-based diet for pacific white shrimp *Litopenaeus vannamei;* Evaluation of polyunsaturated fatty acids and β-glucan containing diet on growth performance and condition factor of pabdah catfish, *Ompok pabda* (Hamilton, 1822); Feed efficiency and growth of catfish (*Clarias* sp.) fed with the addition of immune-boosting fermented earthworms**;** Eetection and genotype determination of lymphocystis disease virus infecting orange clownfish, *Amphiprion percula* farmed in Batam, Indonesia.

These scientific papers are expected to contribute to and fill the gap of the body of knowledge in the field of aquaculture. Most importantly, the information contained in the current publication can make a significant impact on the decision making of policy makers and managers to manage and develop aquaculture in Indonesia and worldwide. As the Editor-in-Chief, I would like to extend a sincere gratitude to the contri-buting researchers in this volume.

Editor-in-Chief

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COMPARISON OF PRODUCTION PERFORMANCE OF STRIPED CATFISH LARVAE (*Pangasianodon hypophthalmus*, Sauvage 1878) FED WITH LIVE AND FROZEN DAPHNIA (*Daphnia magna*)

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ABSTRACT

Daphnia magna as a live feed in the maintenance of striped catfish larvae in the form of frozen feed is still limited. Evaluation of the production performance of striped catfish larvae using live feed *D. magna* in both live and frozen compared with feeding Tubifex became the objective of this research activity. The experimental design used feed treatment with Tubifex (P1) as a control, live *D. magna* (P2), and frozen *D. magna* (P3) with four experimental replications for 15 days of rearing using a completely randomized design. Twelve aquariums with a water volume of 150 L were used in the experiment. Striped catfish larvae (1.5 cm TL), as many as 9 fish/L were stocked in each aerated aquarium. The amount of feed given was 15% of the weight of fish biomass with a frequency of 4 times a day and increased every day by 10% from the total feed of the first day. Results of the experiment showed different feeding significantly affected absolute length growth, total biomass, and feed conversion, with the best treatment being Tubifex (P1) with values of 0.6 ± 0.02 cm, 83.93 ± 5.99 g, and 1.31, respectively. The best growth rate of weight and length were obtained on larvae fed Tubifex (P1). The best protein efficiency and retention ratio resulted from frozen *D. magna* feed (P3) treatment of 12.45 and 7.11%, respectively. Live and frozen *D. magna* was not significantly different, so frozen *D. magna* feed can be used as an alternative natural feed with a high level of availability.

KEYWORDS: ***Daphnia magna*; striped catfish; production performance; frozen Daphnia**

INTRODUCTION

The total diversity of catfish families in Indonesia is 36, spread across Java, Sumatra and Kalimantan , including *Pangasianodon hypophthalmus,* Sauvage 1878 (*Striped catfish*), one of the types introduced from Thailand (Gustiano *et al*., 2003; Widayanti *et al.*, 2022). The community widely cultivates striped catfish because it has a high tolerance for water quality conditions and fecundity (Ariyanto *et al*., 2012).

Feeding is one factor that supports the success of catfish larvae rearing activities. Feeding with adequate protein as an indicator is one of the supporting factors in growth, fish condition, and production quality (Tahapari & Darmawan, 2018). According to Exstrada *et al*. (2020), the problem encountered in the rearing of striped catfish is the high mortality of fish larvae after passing through the egg yolk phase as food reserves run out and nutritional intake from outside begins.

Several studies have been conducted about live food provided for the maintenance of catfish larvae such as Artemia, Moina, Daphnia, and Tubifex in the form of live feed obtained significant results in the growth and survival of catfish larvae (Effendi *et al*., 2006; Exstrada *et al*., 2020; Idawati *et al*., 2018). In the initial rearing phase for striped catfish larvae, maintenance is carried out for 20-45 days from hatching, with a survival rate of 30-50% (Nguyen *et al*., 2013).

Several factors influencing the rearing of catfish larvae and larvae include containers, larvae, feed, and water (Boyd & Tucker, 1998; Carter, 2015; Lekang, 2013; Nguyen *et al*., 2013). Some of the live feed used during the rearing of larvae were *Artemia*, *Moina*, and *Tubifex* sp with the amount of giving 4-5 times a day (Nguyen *et al*., 2013). In addition, live feed Daph-

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nia is often used for catfish larvae as a source of nutrition (Carter, 2015; Prasetya *et al*., 2010).

Tubifex is one of the live feeds that are widely used in catfish nurseries. However, with the high demand for the use of Tubifex, the level of availability of Tubifex is still limited where the fulfilment of the demand for its needs is still mostly met from natural catches, causing a void in catfish larvae production (Jusadi *et al*., 2015; Suprayudi *et al*., 2015). Therefore, it is necessary to have other live feed alternatives that can be used in nursery activities for catfish larvae so that live feed can be continuously available.

However, a problem that arises when cultivating *D. magna* is the low yield of *D. magna* (Hasan & Kasmawijaya, 2021). Of course, this has implications for the need for *D. magna* as a live food, along with increasing aquaculture activities that increase the availability of *D. magna. D. magna* was fulfilled from natural catches.

Fulfilling the need for live feed apart from increasing *D. magna* production, the provision of live and frozen *D. magna* (Ahmadvand *et al*., 2012; Ojutiku, 2008; Pangkey, 2009) can be an option in maintaining the continuity and sustainability of the availability of live feed needed. With the high dependence on striped catfish larvae as live food, there is a need to find live food sources continuously and sustainably. This study aims to figure out and compare the performance of striped catfish larvae production with live and frozen daphnia feeding so that frozen daphnia can be an alternative natural feed with a high level of availability.

MATERIAL AND METHODS

Experiment Design

The experimental design used a completely randomized design with three treatments and four replications, namely *Tubifex* sp (P_1), live *D. magna* (P_2), and frozen *D. magna* (P_3). Twelve aquariums with a water volume of 150 L were stocked with striped catfish larvae size 1.5 cm with a weight of 0.04 g, as many as 9 fish/L in each aerated aquarium.

The experimental feed P_1 is Tubifex from nature which cultivators have widely used. Experimental feed P_2 and P_3, namely *D. magna* from cultivation with commercial feed with ± 30% protein. Harvested *D. magna* is inserted into a container (tray) with size 150 x 108 x 13 mm and then frozen for at least seven days.

The amount of feed given was 15% of the weight of fish biomass with a frequency of 4 times a day and increased every day by 10% of total feed at the first day (Nguyen *et al*., 2013). The nutritional composition of the experimental feed can be seen in Table 1.

Table 1. Nutritional composition of experimental feed

Nutrient composition (% wet weight)	Experimental feed [1]		
	P_1	P_2	P_3
Moisture	78.62	93.94	94.14
Crude protein	11.62	3.04	2.86
Crude fat	2.13	0.62	0.56
Ash	0.88	0.81	0.82
[2)] Carbohydrates	6.75	1.60	1.61

[1)] Treatments P_1 (Tubifex), P_2 (live *Daphnia*), and P_3 (frozen *Daphnia*).

[2)] Carbohydrates (%) = 100 – (protein + fat + ash) %

Siphoning is conducted daily to avoid the accumulation of feed residues and dirt at the bottom of the rearing container. Water exchange is carried out every two days for as much as 25% of the container water. The rest of the feed was siphoned every 1 hour after feeding at each feeding time. The rest of the feed was dried and then weighed to see the amount of feed consumed. At the end of maintenance, harvesting will be carried out, and then the average length and weight of the fish will be measured. The total weight of the fish is weighed for one container then the weight is averaged and 45 sample of fish were measured for total length (5%).

Production Performance

Measurement of production performance is seen from several parameters, including specific growth rate (length and weight), weight and length gain, survival, feed conversion, protein efficiency, and protein retention. Measurements were made by taking samples from the rearing container at the end of the experimental maintenance, measuring the length of the fish using a digital calliper with an accuracy of 0.1mm, and measuring the weight of the fish using a digital scale with an accuracy of 0.01g.

The specific growth rate (length and weight) were calculated using the formula according to (Vu & Huynh, 2020) as follows:

$$L - SGR\ (\%) = \frac{\ln\left(\frac{\text{Final length}}{\text{Initial length}}\right)}{\text{Trial day}} \times 100 \qquad (1)$$

$$W - SGR\ (\%) = \frac{\ln\left(\frac{\text{Final weight}}{\text{Initial weight}}\right)}{\text{Trial day}} \times 100 \qquad (2)$$

The absolute length growth is calculated using the following formula (Meidi *et al*., 2019):

$$L = \text{Final length} - \text{Initial length} \quad (3)$$

Survival is calculated using the following formula (Effendie, 1997):

$$SR\ (\%) = \frac{\text{Total of fish harvested}}{\text{Total of fish stocked}} \times 100 \quad (4)$$

Calculation of feed conversion ratio (FCR) was carried out using the formula according to (Tanjung *et al*., 2020) as follows:

$$FCR = \frac{\text{Total feed (g)}}{\text{Total final biomass (g)}} \quad (5)$$

Calculation of protein efficiency ratio (PER) using the formula according to (Suryanti *et al*., 2003) as follows:

$$PER = \frac{\text{Weight gain (g)}}{\text{Total protein of feed (g)}} \quad (6)$$

Calculation of protein retention (PR) by using the formula according to (Allam *et al.*, 2020; Viola & Rappaport, 1979) as follows:

$$PR\ (\%) = \frac{\text{TP of final fish} - \text{TP of initial fish}}{\text{TP consumed (g)}} \times 100 \quad (7)$$

where: TP = Total protein

The calculation of the length-weight relationship uses the following formula:

$$W = aL^b \quad (8)$$

where:
W = Total weight (g)
L = Total length of fish (cm)
a = Growth index constant
b = Coefficient of growth

The condition factor is calculated using the following formula:

$$K = \frac{100\ W}{L^3} \quad (9)$$

where:
K = Condition factor
W = Total weight of fish (g)
L = Total length (cm)

Proximate Analysis of Experimental Feed and Catfish Larvae

The feed used was evaluated for nutritional composition before being used. The experimental catfish larvae, as many as 100, will be tested for their nutritional content at the end of rearing. The test is carried out based on the Indonesian National Standard (SNI) following the method of Official Methods Chapter 4 (AOAC, 2005). Crude protein was tested using the Kjeldahl method and ash content using an ashing furnace at a temperature of 600 °C for 4 hours. Fat content using Soxhlet fat extraction, ash content using an electric furnace at 600 °C for 1 hour, and moisture content being tested using an oven at 65 °C for 24 hours.

Water Quality

During the maintenance period, the water quality in the aquarium is checked periodically. Water changes was conducted every two days with 25% of the total volume. Parameters measured included temperature and oxygen using an *oxygen meter* (Lutron DO-5510), and pH was measured using a pH meter (Pen type PH-009 (1) A) every three days. Meanwhile, ammonia, nitrite, and nitrate were tested in the laboratory using the spectrophotometric method at the end of the experiment.

Statistical Analysis

Data will be evaluated using One-way *ANOVA* and Least Significance Difference (LSD) to determine the level of effect of differences between experimental feed treatments with a probability of 5% ($p < 0.05$) using a linear equation model (Steel & Torrie, 1980):

$$Y_{ij} = \mu + X_i + \alpha_{ij} \quad (10)$$

where:
Y_{ij} = Data from the observation of the i-th treatment and the j-th replication
μ = mean of a population
X_i = effect of treatment i
α_{ij} = treatment error i-th and j-th replication
i = treatment (X_1, X_2, X_3)
j = replication (1, 2, 3)

Linear regression analysis was used to evaluate the growth pattern of fish larvae using the length-weight relationship (allometric) method and condition factors.

RESULTS AND DISCUSSION

The condition of water quality in the container during the 15-day maintenance period can be seen in Table 2.

Water quality parameters of temperature, pH, and dissolved oxygen follow the optimal standards for rearing catfish larvae (Carter, 2015; Nguyen *et al*., 2013). Different feeding had no significant effect on

Table 2. Water quality parameters during the maintenance of each treatment

Parameters	Treatment [1)]		
	P_1	P_2	P_3
Temperature (^oC)	24.3 - 25.4	24.3 - 25.4	24.3 - 25.4
pH	6.86 - 8.39	7.33 - 8.35	7.32 - 8.39
Dissolved oxygen (mg/L)	4.2 - 6.7	4.4 - 6.9	4.4 - 7.6
TAN (mg/L)	0.045 ± 0.001	0.046 ± 0.001	0.046 ± 0.000
Nitrite (mg/L)	0.508 ± 0.147	0.410 ± 0.068	0.508 ± 0.224
Nitrate (mg/L)	7.504 ± 0.216^c	6.812 ± 0.461^{ab}	6.307 ± 0.537^a

The values in the row with the same letter notation are not statistically significant ($p > 0.05$)
[1)] Treatments P_1 (Tubifex), P_2 (live Daphnia), P_3 (frozen Daphnia).

ammonia and nitrite concentration in rearing water ($p > 0.05$). However, different feeds had a significant effect on nitrate concentration ($p < 0.05$), where the highest concentration was found in the Tubifex feed treatment (P_1). Nitrate concentration results from the nitrite and ammonia nitrification process (Boyd & Tucker, 1998). The availability of dissolved oxygen concentration in the media in all experimental containers kept the ammonia and nitrite concentrations within the tolerance threshold (Boyd & Tucker, 1998). The nitrite concentration in all experimental feeds ranged from 0.310–0.580 mg/L, and the fish larvae were still in healthy condition. Several research results indicate that larvae of striped catfish have a high tolerance level of ammonia and nitrite (Slembrouck *et al*., 2009). Several research activities that have been carried out reported the level of nitrite and ammonia concentrations varies between 0.2–7.5 mg/L nitrite and 0.5–1.0 mg/L ammoniac (Slembrouck *et al*., 2009) for striped catfish larvae, 0.001 – 0.006 mg/L nitrite and 0.14–0.27 mg/L ammoniac (Jayant *et al*., 2018) for striped catfish juvenile, 0.47–0.70 mg/L nitrite and 0.31–0.48 mg/L ammoniac (Islam *et al*., 2021) for striped catfish juvenile.

Based on data in Table 3, feeding different types of feed has a significant effect on production performance of catfish. On absolute length growth parameters, total biomass, and FCR, experimental Tubifex feed (P_1) get the best results. The length of fish at the end of rearing is 8-10% longer with an absolute length growth of 0.6 ± 0.02 cm than the experimental feed of live *D. magna* (P_2) and frozen *D. magna* (P_3) with a more effective and efficient feed conversion rate. The three experimental feeds had no significant effect on survival rate ($p > 0.05$), with the best value being the live *D. magna* feeding treatment (P_2), with a survival rate of 97.43%.

Comparing the length and weight growth rate, the protein efficiency and protein retention ratio between different feedings had a significant effect ($p < 0.05$). The best results for the specific growth rate (length and weight) were obtained in treating Tubifex feed (P_1) with a specific-weight growth rate (W-SGR) of 8.02% and a specific-length growth rate of 2.24%. However, the best results of protein efficiency and protein retention were obtained from the feed treatment frozen *D. magna* (P_3) higher than other treatments (Table 4). The different feeds given to the protein content of striped catfish had no significant effect ($p > 0.05$) (Table 5).

The length-growth rate and protein efficiency ratio of striped catfish for all experimental feeds showed satisfactory result. Based on research on striped catfish larvae, where the specific growth rate is 1.60–1.63% (Jayant *et al*., 2018) and the protein efficiency ratio is 3.40 (Tahapari & Suhenda, 2009) .

Based on the study results, feed using Tubifex had good effects on growth performance. This result is due to Tubifex has different in protein content (11.62 %) and higher than the protein content of *D. magna* (Table 1) with the same feeding doses in wet weight conditions. At the same level of administration, the amount of protein intake will be different on the impact on the rate of protein intake and different fish growth. This result follows several research results where protein content in feed affects the growth of fish weight and length in several types of fish (Jayant *et al*., 2018; Tahapari & Darmawan, 2018; Siddiqui & Khan, 2009; Slembrouck *et al*., 2009). The need for protein feed for a good growth rate for striped catfish larvae with a stocking size of 4.21 g was 37.1% (Jayant *et al*., 2018) and for catfish larvae with a stocking size of 33.6 g, it was in the range 23–32% (Poernomo *et al*., 2015).

The growth pattern of catfish larvae was based on the length-weight relationship. The experimental Tubifex feed (P_1) had a positive allometric growth pattern ($b > 3$). The allometric equation $W = 1.2\ 10^{-5}\ L^{3.0654}$ with a correlation coefficient value of $R^2 = 0.915$ (Figure 4.A). While the experimental feed of live *D.*

Table 3. Catfish larvae production performance with different feeding

Production parameters	Treatment [1]		
	P_1	P_2	P_3
Final weight [2] (g)	0.133 ± 0.006[c]	0.083 ± 0.001[a]	0.083 ± 0.003[ab]
Final length [3] (cm)	2.09 ± 0.02[c]	1.92 ± 0.05[ab]	1.89 ± 0.01[a]
Absolute length growth (cm)	0.6 ± 0.02[c]	0.43 ± 0.05[ab]	0.4 ± 0.01[a]
Total biomass increase (g)	83.93 ± 5.99[c]	38.7 ± 1.27[a]	38.93 ± 2.25[ab]
Feed conversion	1.31 ± 0.09[c]	2.83 ± 0.09[ab]	2.82 ± 0.15[a]
Survival rate (%)	95.65 ± 2.53[a]	97.43 ± 2.15[abc]	96.68 ± 2.42[ab]

The values in the row with the same letter notation are not statistically significant ($p > 0.05$)
[1] Treatment P_1 (Tubifex), P_2 (live Daphnia), P_3 (frozen Daphnia)
[2] Average fish weight at the end of the study
[3] Average fish length at the end of the study

Table 4. Growth rate, protein efficiency and protein retention of catfish larvae fed with different diets

Production parameters	Treatment[1]		
	P_1	P_2	P_3
W-SGR [2] (%)	8.02 ± 0.33 [c]	4.87 ± 0.11 [ab]	4.88 ± 0.2 [a]
L-SGR [3] (%)	2.24 ± 0.08 [c]	1.68 ± 0.16 [ab]	1.58 ± 0.03 [a]
Protein efficiency ratio/PER	6.6 ± 0.47 [a]	11.64 ± 0.38 [b]	12.45 ± 0.72 [bc]
Protein retention (%)	3.88 ± 0.27 [a]	6.77 ± 0.25 [b]	7.11 ± 0.42 [bc]

The values in rows with the same letter notation are not statistically significant ($P > 0.05$)
[1] Treatment P_1 (Tubifex), P_2 (Live *Daphnia*), P_3 (Frozen *Daphnia*)
[2] W-SGR: Specific Weight Growth Rate
[3] L-SGR: Specific Length Growth Rate

Table 5. Proximate composition of Striped catfish with different feeding

Chemical parameters (%, dry weight)	treatment[1]			*P value*
	P_1	P_2	P_3	
Crude Protein	58.75 ± 0.10	58.14 ± 0.41	57.11 ± 0.08	0.26
Crude Fat	6.40	8.54	8.28	
Ash	13.20	15.45	15.86	
Carbohydrates [2]	21.65	17.87	18.75	

[1] Treatment P_1 (Tubifex), P_2 (Live *Daphnia*), P_3 (Frozen *Daphnia*)
[2] Carbohydrates: 100 – (Protein + Fat + Ash)

magna P_2 and frozen *D. magna* P_3 had a negative allometric growth pattern ($b < 3$). The allometric equations respectively $W = 2.6\ 10^{-5} L^{2.7407}$ with correlation coefficient $R^2 = 0.820$ (Figure 4.B) and $W = 1.8\ 10^{-5} L^{2.8660}$ with correlation coefficient $R^2 = 0.655$ (Figure 4.C). The highest condition factor was in the experimental Tubifex feed (P_1), which was 1.41 (Table 6). This result means that in the growth pattern for the treatment of Tubifex feed (P_1), weight growth was more dominant than the length increase, while the live *D. magna* (P_2) and frozen *D. magna* (P_3) had a more dominant growth pattern in length than weight. (Okomoda *et al*., 2018) found that the allometric growth pattern of striped catfish is negative, with a value of $b = 2.931$ with a correlation coefficient of $R^2 = 0.916$. Growth patterns and fish condition factors are influenced by fish biological conditions such as (sex, age, and size), water quality parameters, and food availability in the rearing media (Froese, 2006; McKenzie *et al*., 2007; Nehemia & Maganira, 2012; Okomoda *et al*., 2018). Based on this, the availability of food in the rearing media in the present study, where the amount of protein intake in the treatment of Tubifex (P_1) is higher than the live *D. magna* (P_2)

Table 6. Length-weight relationships of catfish larvae fed with different feeds.

Treatment	n	a	b	Growth pattern	K[1] Mean ± SD[2]
Tubifex feed (P_1)	100	1.2 10^{-5}	3.0654	Positive allometric	1.41 ± 0.17
Live daphnia feed (P_2)	100	2.6 10^{-5}	2.7407	Negative allometric	1.23 ± 0.16
Frozen daphnia feed (P_3)	100	1.8 10^{-5}	2.8660	Negative allometric	1.22 ± 0.21

[1] K: condition factor

[2] SD: Standard Deviation

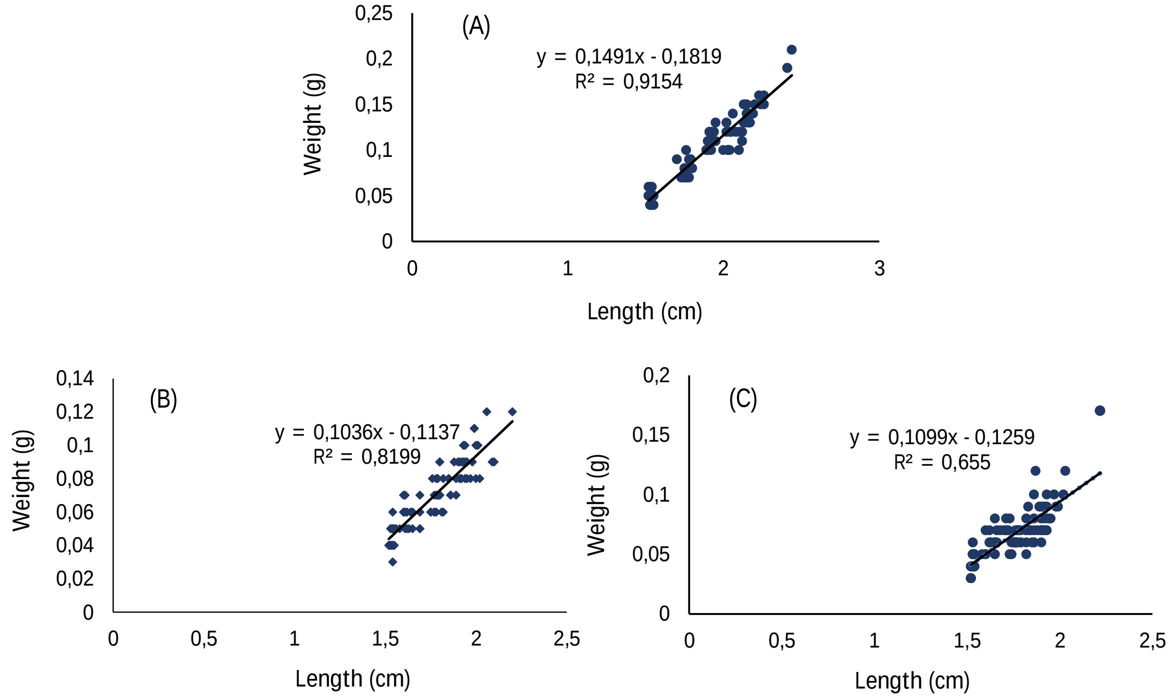

Figure 1. Length-weight relationships of catfish fed with different feeds in laboratory rearing conditions, A) Tubifex feed; B) Live *Daphnia* feed; C) Frozen *Daphnia* feed.

and frozen *D. magna* (P_3) treatments, causing the condition factor in P_1 to be greater than P_2 and P_3.

CONCLUSION

Tubifex feeding had a better production performance at the same amount of feeding than live or frozen *D. magna* feed. However, *D. magna* feed has a better protein efficiency and retention level, so it can be considered as a substitute feed for Tubifex feed with an adjusted feeding amount. Further research on *D. magna* can be carried out to determine and evaluate the need for the right amount of *D. magna* feed for catfish larvae to obtain better production performance.

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