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Effect of fish meal replacement by zooplankton and *Daphnia* meal on growth performance parameters of the white leg shrimp, *Penaeus vannamei*

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ABSTRACT

The purpose of this research was to determine how well zooplankton meal (ZM) and *Daphnia* meal (DM) might replace fish meal (FM) in the diet of white leg shrimp, *Penaeus vannamei*, without negatively impacting the shrimp's growth performance or feed intake. A total of 315 shrimp fry were employed, and the shrimp were randomly assigned to one of seven treatment groups, with three replicates per group. Here are the seven diets that were tested: C = fed commercial diet (control group); Z = fish meal replaced by zooplankton meal at 25%, 50%, and 75%; and D = fish meal replaced by Daphnia meal at 25%, 50%, and 75%. The protein composition of all the experimental diets was equalised by structural adjustments (40 % protein). Z_{50} and D_{75}, in which 50% and 75% of fishmeal were replaced by zooplankton meal and Daphnia meal, respectively, showed the highest values of growth performance parameters (final length, length gain, final weight, weight gain, and daily weight gain) and feed utilisation parameters (food conversion ratio, feed efficiency ratio, and protein efficiency ratio).The larvae of White leg shrimp, *Penaeus vannamei*, showed substantial improvements in growth performance and feed utilisation metrics when fishmeal was replaced with zooplankton meal or Daphnia meal.

INTRODUCTION

The rising need, particularly for animal protein, highlights the growing significance of fish as a dietary source. Fish farm development has received much focus. Farms like this have the potential to help meet the growing demand for animal-based proteins in human diets **(Azab *et al*., 2005; Cottrell *et al*., 2020)**. Particularly useful as a protein source in areas with a shortage of cattle. In North America and Europe, fish accounts for less than 10% of animal protein consumption; in Africa, 17%; Asia, 26%; and China, 22%. According to the Food and Agriculture Organization, fish is the principal source of animal protein for almost one billion people throughout the globe **(World Fish, 2020)**. In 2016, it was anticipated that Egypt produced 1706273 tonnes of fish altogether; 80% came from aquaculture and 20% came from wild fisheries. 68.6 percent of Egypt's entire aquaculture and natural output is made up of Nile Tilapia, *Oreochromis niloticus* **(GAFRD, 2016; Hassan *et al*., 2020)**.

There are more than 62 different species of crustaceans that have been successfully farmed. Sixty-eight percent of all crustaceans are grown in aquaculture. Inland aquaculture accounts for the remaining 39.2 percent of total output **(FAO, 2012; Verdegem *et al*., 2023)**.

In aquaculture, penaeid shrimps are highly prized, and huge areas are devoted to shrimp production **(Karuppasamy & Mathivanan, 2013; Macusi *et al*., 2022)** reason being its universally high demand. *Penaeus vannamei* **(Boone, 1931)** is the most widely produced shrimp in Central and South American nations, China, and Thailand, and accounts for over 90% of all shrimp farmed in the western hemisphere **(Frias-Espericueta *et al*., 2001; Mc Graw *et al*., 2002; Saoud *et al*., 2003)**.

Penaeus vannamei is the most important penaeid shrimp species farmed on earth **(Alcivar Warren *et al*., 2007)**, cultivated more than any other shrimp species in the Western Hemisphere. About 90% of all cultivated shrimp come from this species; it is by far the most popular choice for shrimp farms in Central and South American nations **(Wurmann *et al*., 2004)**.

Improvements in product quality and maximum growth rates are possible with proper fish nutrition, making this an important consideration for the burgeoning Mediterranean aquaculture business **(Parpoura & Alexis, 2001)**. The primary goal in developing a fish diet is to give a cost-effective combination of components that promotes the animal's maintenance, growth, reproduction, and health **(NRC, 1993)**. For formulations to be cost-effective, they need to take into account our understanding of dietary needs (because feed is one of the main expenditures in feed production; **Lupatsch *et al*., 2001)**. Environmental, social, and dietary variables all play a role in fish reproduction, just as they do in other vertebrates. Several economically significant aquaculture species have had their reproductive success studied in relation to dietary ration size and nutritional content **(Kjorsvik *et al*., 1990; Bromage *et al*., 1992)**. Exogenous variables such as food quality and quantity have significant effects on fish fitness because they directly impact growth and, indirectly, maturity and mortality **(Wootton, 1990)**.

The most costly part of the diets of fish and other aquatic animals is the protein. Protein supply, pricing, adulteration, and improper treatments during diet production are major issues in the aquaculture sector worldwide, particularly in Egypt and underdeveloped nations **(GAFRD, 2012)**.

For this reason, it seems that plankton is an excellent resource for the exogenous enzymes and immune systems of larvae. When it comes to raising healthy fish larvae, juveniles, and fry, however, the nutritional content of plankton varies and plays a vital influence **(van der Meeren *et al*., 2008)**. Success of the aquaculture environment may be measured, in part, by studying zooplankton populations in fish farming systems **(Tavares *et al.*, 2010; Ssanyu *et al.*, 2011)**.

So, the present study was aimed to to evaluate the effect of replacing fish meal (FM) in the shrimp diet with zooplankton meal (ZM) and Daphnia meal (DM) on the growth performance and feed utilization of white leg shrimp, *Penaeus vannamei.*

MATERIALS AND METHODS

1. Experimental shrimp:

In the current experiment, 315 shrimp fries of white leg shrimp, *Penaeus vannamei* **(Fig. 1)** were used (seven treatments, three replications at a rate of 15 individuals/tank). They were divided as seven different treatments (Control, Z_{25}, Z_{50}, Z_{75}, D_{25}, D_{50}, D_{75}). The average of Initial length was 0.91±0.015 mm and initial weight was 0.013±0.001 g.

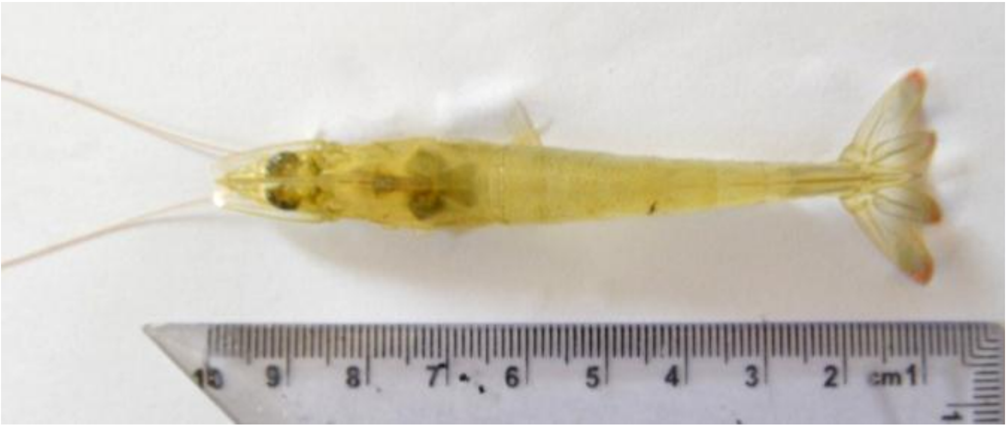


Fig. (1). A photograph of the white-leg vannamei shrimp (*Penaeus vannamei*)

2. Experimental management:

The initial stages of the shrimp were placed in fiberglass tanks of a capacity of one m^3 in water for acclimatization during the period of two weeks. Afterward, the shrimps were distributed in plastic culture tanks of 100 liters of water at rates of 15 individuals per tank to be settled in the intensive culture system, approximately 50 individuals per 1 m^2 of water. Natural lighting was used during daylight without artificial lighting because shrimp is one of the organisms that increase their activity at night in periods of darkness.

All of the water quality parameters were maintained at levels suitable for growing Penaeus vannamei larvae throughout the experiment. The parameters we measured were as follows: temperature (24–26 °C), salinity (18–22), dissolved oxygen (DO) (5.40–6.45 mg/L), pH (7.34–7.32), ammonia (NH_3) (0.16–0.30 mg/L), and photoperiods (10–14 hr of light/dark).

Air was blown via a system of pipes and into each tank. Five times a day, the waste from the shrimp was syphoned out. Siphonation was performed on a daily scale to remove the feces, molts, and the remaining food from the bottom of the tanks.

3. Experimental diets:

The meals for the seven groups were generated by substituting zooplankton meal (ZM) and daphnia meal (DM) for fish meal (FM) in the diet:

C: control, fed on commercial diet with 100% FM +0% ZM or 0% DM
Z_{25}: fed on commercial diet with 75% FM +25% ZM
Z_{50}: fed on commercial diet with 50% FM +50% ZM
Z_{75}: fed on commercial diet with 25% FM +75% ZM
D_{25}: fed on commercial diet with 75% FM +25% DM
D_{50}: fed on commercial diet with 50% FM +50% DM
D_{75}: fed on commercial diet with 25% FM +75% DM

About 40% crude protein was included in the experimental meals. Protein was provided by total zooplankton meal, Daphnia meal, fishmeal, and soy meal (both animal and plant, respectively) **(Tables 1-3)**.

Twenty percent of the cultured shrimp's total weight was fed to them in the first month, ten percent in the second, and seven percent from the third month forward until the completion of the experiment. Five times a day, an equal portion of the daily quota was made available (09.00, 12.00, 15.00, 18.00, and 21.00). The amount of feed consumed was calculated by collecting the leftovers, drying them, and then weighing them.

Table (1): Biochemical compositions of the ingredients used in the experimental diet (% of dry matter)

Ingredients	DM	CP	EE	CF	Ash	NFE[1]	GE[2]	DE[3]
Daphnia meal	92	47.7	10.2	2.1	17.8	22.2	4360	3472
Zooplankton	93	49	12.1	0.9	16.9	21.1	4792	3593
Fish meal	92	60	12.5	0.6	15.4	11.5	5055	3791
Soybean meal	90	45	1.1	7.3	6.3	40.3	4550	3413
Yellow corn	88	10	3.6	2.3	1.3	82.8	4309	3232
Wheat bran	89	14	6.4	9.9	5.3	64.4	4368	3276
Corn gluten	92	60	11	2.1	12	14.9	5110	3832

DM: dry matter; CP: crude protein; EE: ether extract; CF: crude fiber;
[1] NFE: nitrogen-free extract= 100-(CP+CF+EE+Ash%).
[2] G.E., gross energy, calculated according to Jobling (1983), using the 5.65, 9.45, and 4 for CP, EE and NFE, respectively.
[3] DE digestible energy, estimated according to Jobling (1983), using digestible energy = gross energy X 0.75.

Table (2): Ingredients (%) and proximate composition (% of dry matter) of experimental diets used in zooplankton meal experiment

Ingredients (%)	Treatments			
	Control	**Z_{25}**	**Z_{50}**	**Z_{75}**
Fish meal	30	22.5	15	7.5
Zooplankton meal	0	7.5	15	22.5
Soybean meal	27.7	30.5	33	35.2
Wheat bran	16	13.5	12	10.8
Corn meal	13.3	13	12	11
Corn gluten	10	10	10	10
Fish oil	1	1	1	1
Soybean oil	1	1	1	1
Vitamin & mineral premix	1	1	1	1
Proximate composition (%)				
CP %	**40.04**	**40.09**	**40.08**	**39.98**
CF %	3.56	3.75	3.82	3.92
Ash %	12.6	12.3	12.7	12.9
EE %	15.5	15.3	15.4	15.2
NFE %	28.3	28.56	28	28
Total	100	100	100	100
DM %	**93.2**	**92.7**	**93.6**	**92.8**
GE2 (K cal /kg)	**50014**	**50033**	**49926**	**49721**
DE3 (K cal /kg)	**37511**	**37525**	**37445**	**37291**

Fish meal (FM); Zooplankton meal (ZM); Dry matter (DM); Crude protein (CP); Crude fiber (CF); Ether extract (EE); Nitrogen free extract (NFE) ={100- (crude protein +ether extract+ crude fiber +ash)}

Table (3): Ingredients (%) and proximate composition (% of dry matter) of experimental diets used in Daphnia meal experiment

Ingredients (%)	Treatments			
	Control	**D_{25}**	**D_{50}**	**D_{75}**
Fish meal	30	22.5	15	7.5
Daphnia meal	0	7.5	15	22.5
Soybean meal	27.7	31	33	35.2
Wheat bran	16	13	12	10.8
Corn meal	13.3	13	12	11
Corn gluten	10	10	10	10
Fish oil	1	1	1	1
Soybean oil	1	1	1	1
Vitamin & mineral premix	1	1	1	1
Proximate composition (%)				
CP %	**40.04**	**40.15**	**39.89**	**39.68**
CF %	3.56	2.7	2.65	2.75
Ash %	12.6	13.9	13.8	14.1
EE %	15.5	16.6	16.66	16.47
NFE1 %	28.3	26.65	27	27
Total	100	100	100	100
DM %	**93.2**	**94**	**93.5**	**93.6**
GE2 (K cal /kg)	**50014**	**50111**	**50141**	**49883**
DE3 (K cal /kg)	**37511**	**37583**	**37606**	**37583**

Fish meal (FM); Daphnia meal (DM); Dry matter (DM); Crude protein (CP); Crude fiber (CF); Ether extract (EE); Nitrogen free extract (NFE) ={100- (crude protein +ether extract+ crude fiber +ash)}

4. Measurements of growth performance:

Calculations were made for the following Penaeus vannamei metrics: total length, final length, length gain, total weight, weight increase, daily weight gain, specific growth rate, feed intake, food conversion ratio, feed efficiency ratio, protein intake, and protein efficiency ratio:

- Final length (mm):

At the conclusion of the experiment, we recorded the average shrimp length (standard length) for each pond's sample.

- **Length gain (mm/shrimp):**

This equation may be used to determine the length gain:

Length gain (mm)= Final length (mm)- initial length (mm)

- **Daily length gain, DLG (mm/ shrimp /day) = length gain (mm) / period (days)**
- **Final weight (g):** The shrimp weight of each sample from each pond was measured and recorded at the end of the experiment.
- **Weight gain (g/shrimp) WG= Final shrimp weight (g) - initial shrimp weight (g)**
- **Daily weight gain, DWG (mg/ shrimp /day) = weight gain (mg) / period (days)**
- **Specific growth rate, SGR (%/day)= (Ln FW- Ln IW) / period (days) X 100**

Where: Ln= Natural log, FW = average final shrimp weight (g), IW = average initial shrimp weight (g)

- **Feed intake FI (g/shrimp)= ∑(biweekly average shrimp weight X daily feeding rate X 14 days)**
- **Food conversion ratio (FCR)= feed intake (g)/ weight gain (g)**
- **Feed efficiency ratio (FER)= Weight gain (g) / Feed intake (g/shrimp)**
- **Protein intake, PI (g)= feed intake (g) X Protein% in the diet/100**
- **Protein efficiency ratio (PER) = weight gain (g/shrimp)/ protein intake (g).**

5. Statistical analysis:

SPSS for Windows was used for all the statistical analysis **(Kinnear & Gray, 1999)**. The impact of partially replacing fish meal with Daphnia meal D.M. and Zooplankton meal Z.M. was evaluated using a one-way analysis of variance. Dancan's multiple range test also found statistically significant variations between means **(Dancan, 1995)**.

RESULTS

1. Effect of zooplankton replacement on shrimp growth performance:

1.1. Growth in length:

Statistical analysis revealed statistically significant ($P < 0.05$) differences in body length and length increase between groups of white leg shrimp, *P. vannamei* fed on various feed diets (with varied ratios of substituting fish meal by zooplankton meal). Z_{50} had the greatest lengthening (10.77±0.126 mm). The control group averaged the least amount of length gain (9.77±0.126 mm). Z50 also had the highest average length growth (9.87±0.114 mm), whereas the control group had the lowest (8.85±0.116 mm). Daily length gains ranged from 0.105±0.001 mm in the control group to 0.118±0.002 mm in the Z_{50} group **(Table 4** and **Fig. 2**).

1.2. Growth in weight:

The results demonstrated statistically significant ($P < 0.05$) differences in body weight, weight increase, and daily weight gain between groups of shrimp given various dietary compositions. The Z_{50} group had the highest average body weight (6.63±0.07 g), whereas the control group had the lightest (4.40±0.06 g). Z_{50} had the highest weight growth (6.62±0.04 g/fish), whereas the control group had the lowest (4.38±0.04 g/fish). Z_{50} had the highest daily weight increase (78.8±0.85 mg/fish/day), whereas control had the lowest (52.2±0.73 mg/fish/day). Z_{50} had a specific growth rate of 3.19±0.01 per year, whereas the control group's rate was just 2.98±0.02 per annum **(Table 4** and **Fig. 2)**.

1.3. Feed utilization:

The results demonstrated statistically significant ($P < 0.05$) differences in feed utilisation characteristics between shrimp given the same diet vs those fed different diets. Z_{75} had the greatest average feed intake (12.42±0.03 g), whereas the control group had the lowest (9.33±0.06 g). Z_{50} had the greatest food conversion ratio (1.86±0.01), whereas the control group had the worst (2.13 0.005). The average feed efficiency ratio was 0.47 in the control group, but in the Z_{50} group it was 0.54 ($p < 0.001$). When compared to the control group, the Z_{75} shrimp devoured the most protein (4.97±0.02 g) and the least (3.73±0.04 g). Protein efficiency ratio was measured, with Z50 having the highest value (1.35±0.01) and the control group having the lowest value (1.17±0.002) **(Table 4)**.

2. Effect of Daphnia meal replacement on shrimp growth performance:

2.1. Growth in length:

Statistical analysis revealed statistically significant ($P < 0.05$) differences in body length and length increase between groups of white leg shrimp, *P. vannamei* fed on various feed diets (with varied ratios of substituting fish meal by Daphnia meal). D_{75} had the greatest increase in length (10.30±0.05 mm). The control group had the slowest average length gain (9.17±0.029 mm). D_{75} also had the highest average length growth (9.39±0.035 mm), whereas the control group had the lowest (8.25±0.019 mm). D_{75} had the greatest average daily length growth (0.112±0.001 mm) while the control group had the least (0.098±0.000 mm) **(Table 5** and **Fig. 3**).

2.2. <u>Growth in weight:</u>

The results demonstrated statistically significant ($P < 0.05$) changes in body weight, weight increase, and daily weight gain between groups of shrimp given the same diet but with varying amounts of fish meal replaced by Daphnia meal. The D_{75} group had the highest average body weight (6.32±0.07 g), whereas the control group had the lightest (4.43±0.10 g). Weight growth averaged 6.30±0.10 g/fish in the D_{75} group and 4.42±0.10 g/fish in the control group. Daily weight increase was measured, and D_{75} had the highest rate (75±1.19 mg/fish/day) whereas control had the lowest (52±1.19 mg/fish/day). D_{75} had a specific growth rate of 3.15±0.035, which was higher than the control group's rate of 2.99±0.013 **(Table 5** and **Fig. 3)**.

2.3. <u>Feed utilization:</u>

According to these findings, the D_{75} group ingested the most feed each day (12.41±0.06 g). With a ratio of 1.97±0.02 in the D_{75} group and 2.15±0.01 in the D_{25} group, the D_{75} group had the best meal conversion. D_{75} had the greatest feed efficiency ratio (0.51± 0.006). Protein consumption peaked at 4.97±0.006 g in the D_{75} group of shrimp. D_{75} had the highest protein efficiency ratio (1.27±0.01) **(Table 5)**.

Table (4): Effect of replacement of fish meal as a source of protein by zooplankton meal on growth performance and feed utilization of Vannamei shrimp larvae

Treatment	Control	Z_{25}	Z_{50}	Z_{75}
Initial length (mm)	0.91±0.015	0.91±0.015	0.91±0.015	0.91±0.015
Final length (mm)	9.77±0.126^{c}	10.28±0.029^{b}	10.77±0.126^{a}	10.32±0.029^{b}
Length gain (mm)	8.85±0.116^{c}	9.39±0.017^{b}	9.87±0.114^{a}	9.41±0.014^{b}
Daily length gain (mm/shrimp/day)	0.105±0.001^{c}	0.112±0.000^{b}	0.118±0.002^{a}	0.112±0.000^{b}
Initial weight (g)	0.013±0.001	0.013±0.001	0.013±0.001	0.013±0.001
Final weight (g)	4.40±0.06^{c}	6.26±0.05^{b}	6.63±0.07^{a}	6.33±0.04^{b}
Weight gain (g)	4.38±0.06^{c}	6.25±0.05^{b}	6.62±0.07^{a}	6.33±0.04^{b}
Daily weight gain (mg/shrimp/day)	52.2±0.73^{c}	74.4±0.59^{b}	78.8±0.85^{a}	75.3±0.42^{b}
Specific growth rate	2.98±0.02^{c}	3.16±0.02^{ab}	3.19±0.01^{a}	3.14±0.01^{b}
Feed intake (g)	9.33±0.06^{b}	12.31±0.05^{a}	12.31±0.04^{a}	12.42±0.03^{a}
Food conversion ratio	2.13±0.005^{a}	1.97±0.001^{b}	1.86±0.01^{c}	1.96±0.004^{b}
Feed efficiency ratio	0.47±0.001^{c}	0.51±0.001^{b}	0.54±0.001^{a}	0.51±0.001^{b}
Protein intake (g)	3.73±0.02^{b}	4.92±0.02^{a}	4.92±0.01^{a}	4.91±0.01^{a}
Protein efficiency ratio	1.17±0.002^{c}	1.27±0.001^{b}	1.35±0.01^{a}	1.27±0.002^{b}

Values with different superscripts indicated significant differences ($p \leq 0.05$)

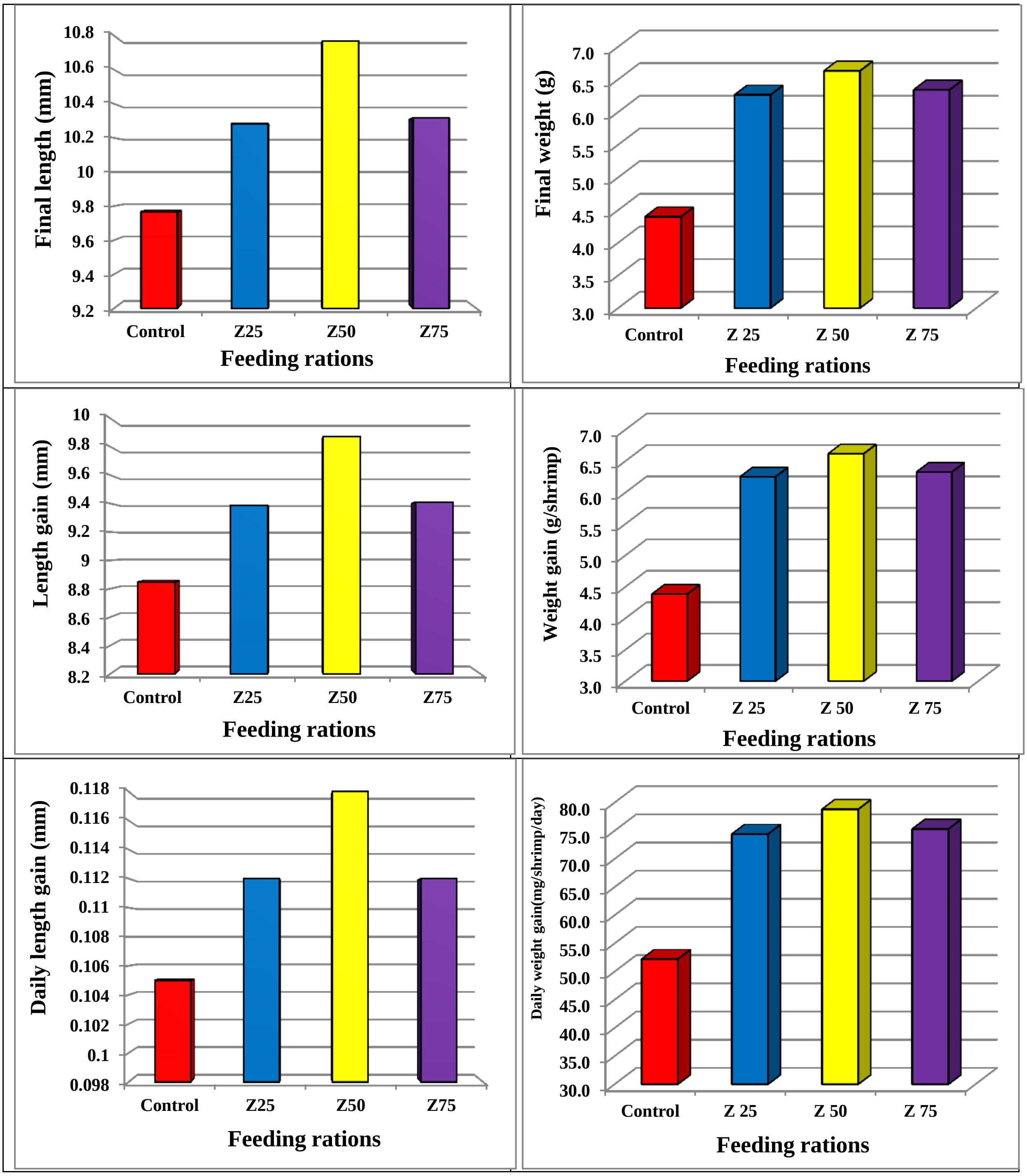
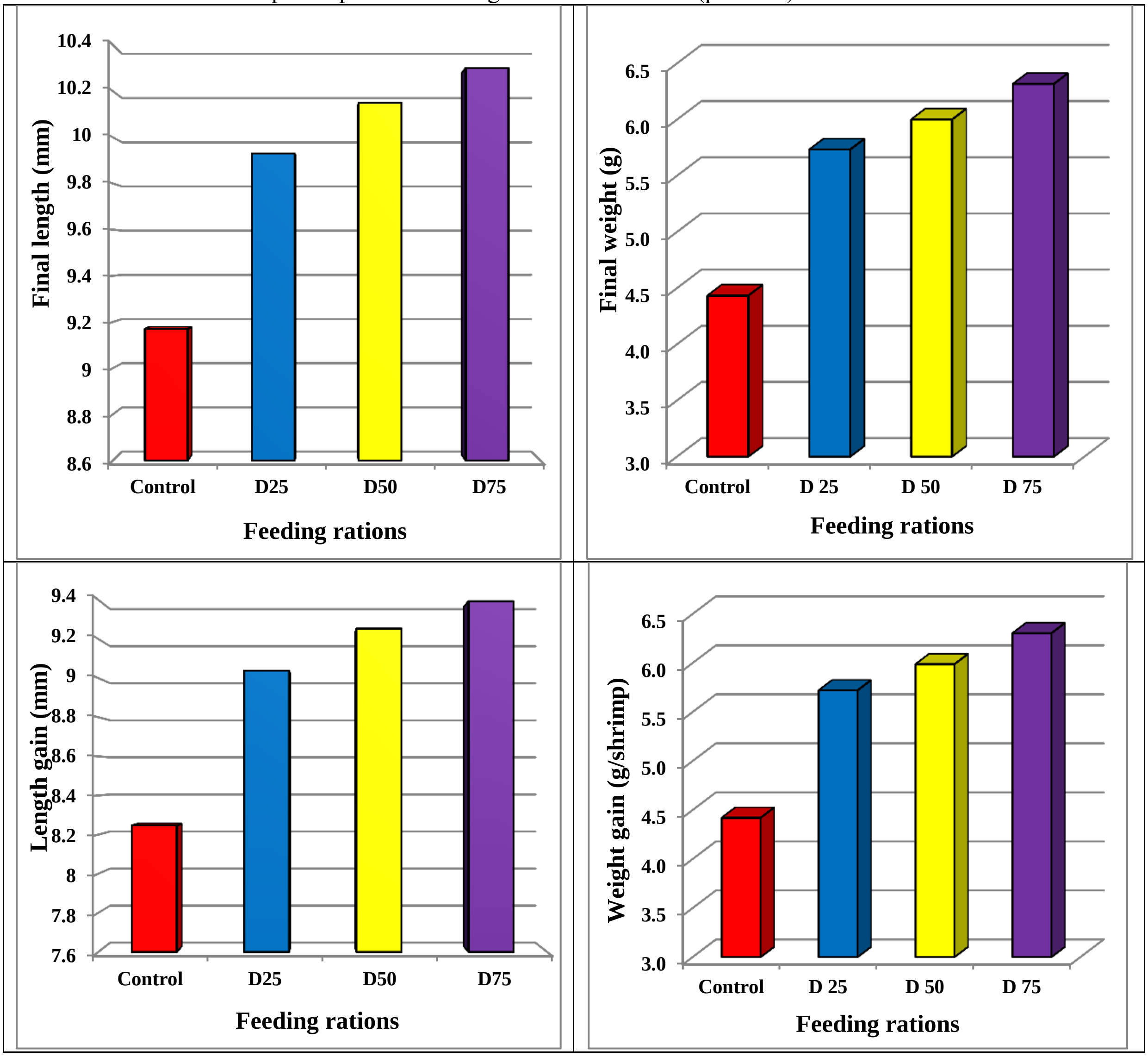


Fig. (2). Effect of replacing fishmeal by zooplankton meal on growth performance parameters of Vannamei shrimp larvae

Table (5): Effect of replacement of fish meal as a source of protein by *Daphnia* meal on growth performance and feed utilization of Vannamei shrimp larvae

Treatment	Control	D_{25}	D_{50}	D_{75}
Initial length (mm)	0.91 ± 0.015	0.91 ± 0.015	0.91 ± 0.015	0.91 ± 0.015
Final length (mm)	9.17 ± 0.029^{d}	9.93 ± 0.029^{c}	10.15 ± 0.05^{b}	10.30 ± 0.05^{a}
Length gain (mm)	8.25 ± 0.019^{d}	9.04 ± 0.017^{c}	9.25 ± 0.038^{b}	9.39 ± 0.035^{a}
Daily length gain (mm/shrimp/day)	0.098 ± 0.000^{c}	0.108 ± 0.000^{b}	0.110 ± 0.001^{b}	0.112 ± 0.001^{a}
Initial weight (g)	0.013 ± 0.001	0.013 ± 0.001	0.013 ± 0.001	0.013 ± 0.001
Final weight (g)	4.43 ± 0.10^{d}	5.73 ± 0.08^{c}	6.00 ± 0.07^{b}	6.32 ± 0.10^{a}
Weight gain (g)	4.42 ± 0.10^{d}	5.72 ± 0.07^{c}	5.99 ± 0.07^{b}	6.30 ± 0.10^{a}
Daily weight gain (mg/shrimp/day)	52.6 ± 1.19^{d}	68.1 ± 0.89^{c}	71.3 ± 0.85^{ab}	75.0 ± 1.19^{a}
Specific growth rate	2.99 ± 0.013^{d}	3.09 ± 0.015^{c}	3.12 ± 0.023^{ab}	3.15 ± 0.035^{a}
Feed intake (g)	9.33 ± 0.1^{b}	12.31 ± 0.09^{b}	12.31 ± 0.06^{b}	12.41 ± 0.06^{a}
Food conversion ratio	2.11 ± 0.03^{a}	2.15 ± 0.01^{a}	2.06 ± 0.03^{b}	1.97 ± 0.02^{c}
Feed efficiency ratio	0.47 ± 0.006^{c}	0.46 ± 0.003^{c}	0.49 ± 0.006^{b}	0.51 ± 0.006^{a}
Protein intake (g)	3.73 ± 0.04^{b}	4.92 ± 0.04^{b}	4.92 ± 0.03^{b}	4.97 ± 0.02^{a}
Protein efficiency ratio	1.18 ± 0.01^{c}	1.16 ± 0.006^{c}	1.22 ± 0.02^{b}	1.27 ± 0.01^{a}

Values with different superscripts indicated significant differences ($p \leq 0.05$)



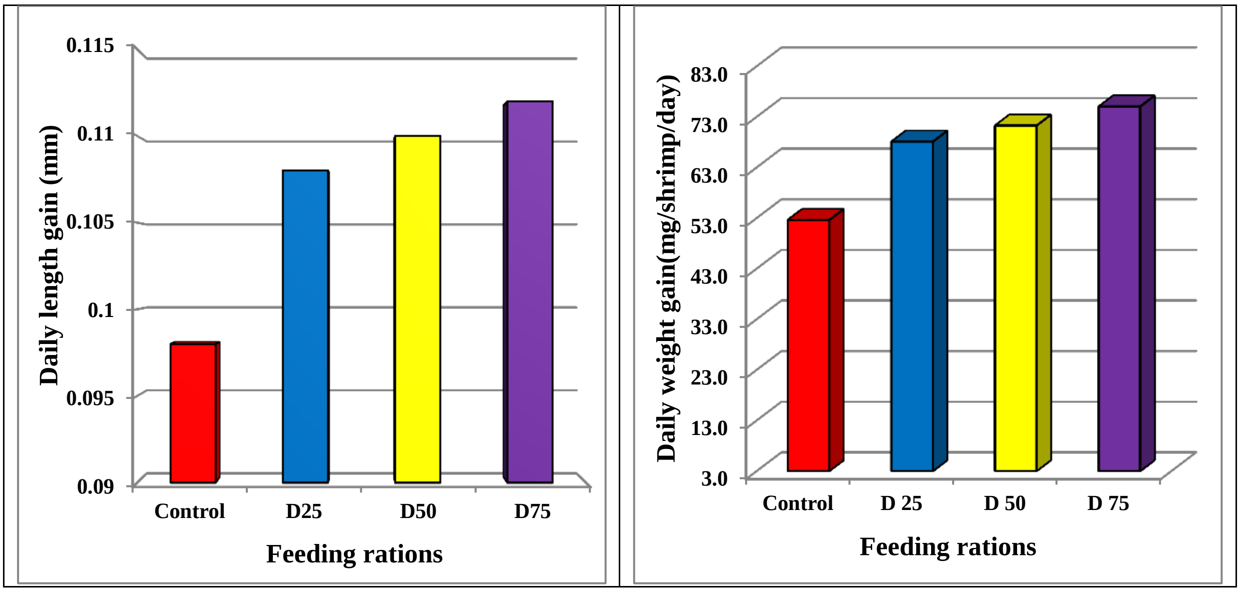


Fig. (3). Effect of replacing fishmeal by Daphnia meal on growth performance parameters of Vannamei shrimp larvae

DISCUSSION

Due to its high protein content, zooplankton meal has been proposed as a potential replacement for conventional animal proteins in the diets of farmed fish **(Perrone *et al*., 2003** and **Baeza-Rojano *et al*., 2014)**. Protein-based meals based on zooplankton or crustaceans have been the subject of many studies as potential replacements for fishmeal in aquatic diets **(; Welcomme, 2011; Guerra-García, *et al*., 2016; Lolas, *et al*., 2018; El-feky & Abo-Taleb, 2020)**; fermented soybean meal **(Van Nguyen, *et al*., 2018)**; lipid-extracted microalgae **(Sarker *et al*., 2018)**; poultry by-product **(Doughty *et al*., 2019)**; insect meal **(Mastoraki, *et al*., 2020)** and silages of fishery by-products **(Lanes& Parisi, 2021)**.

To the best of our knowledge, there is currently no commercially available diet for white leg shrimp, Penaeus vannamei larvae that includes DM as a substitute for FM, either in whole or in part. Recent research has shown that white leg shrimp (*Penaeus vannamei*) larvae may survive on a diet consisting of up to 75% Daphnia meal and 50% Zooplankton meal instead of FM. Fish given a diet higher in Zooplankton and Daphnia outperformed those fed a control diet in terms of growth performance, feed consumption, carcass composition, and diet preparation cost (D_0). Different zoo technical performance measures improved more in the D_{75} group than in the 50% group or the 25% group, and all three groups outperformed the control group (D_0). Additionally, Z50%, Z75%, and Z25% were all greater than the control group overall and each other (D_0).

These results provided further evidence that zooplankton and Daphnia are a viable alternative to FM as a protein source in the diet of white-leg shrimp. Similarly, Pelteobagrus fulvidraco's growth performance, PER, and FCR were greatly enhanced when fish meal was replaced with DMM at concentrations up to 60% **(Zhang *et al*., 2019)**. Supplementing common carp's diet with *D. magna* and spirulina, Arthrospira platensis increased both the fish's growth rate and its total biomass **(Suantika *et al*., 2016)**. Furthermore, compared to the control group, barramundi, Lates calcarifer, given diets containing 5-10% *D. similis* meal showed increased immune surveillance and disease resistance **(Chiu, *et al*., 2015)**. Improvements in growth, feed utilisation, and immuno-biochemical parameters were seen when 5 percent DMM was added to the diet of common carp (*Cyprinus carpio*) **(Abdel-**

Tawwab *et al.*, 2020). *A. persicus* (*Persian sturgeon*) growth performance and feed consumption were dramatically enhanced when *D. magna* was used as a nutritional bag for *S. cerevisiae* **(Soltani, 2012)**.

FM replacement with bone and meat meal up to 50% has been shown in several prior research on various fish species **(Moutinho *et al*., 2017)**, black soldier fly pre-pupae meal up to 22.5% **(Magalhães *et al.*, 2017)**, meat and blood meal up to 80% **(Millamena, 2002)**, and hydrolyzed feather meal up to 25% **(Psofakis *et al.*, 2020)** without compromising fish performance, feed utilization, and improving economic revenue. Nile tilapia diet costs were also decreased by increasing the gambusia meal content. Although gambusia had lower costs per unit of weight gain than the control and other replacement levels, the cost-benefit analysis showed that it could only replace 50% of FM **(Abdelghany, 2003)**. Dourado, *Salminus brasiliensis*, had the greatest financial success when chicken by-product meal replaced 31.6% of the fish meal in their diet **(Donadelli, *et al*., 2019)**. Interestingly, the current results showed that white leg shrimp performance and economic gain positively followed the use of zooplankton meal or Daphnia as an FM replacer. As a consequence, our research may help shape how this novel protein source is used in the manufacturing sector. Therefore, it is important to take precautions to avoid depriving predators of their natural food source by harvesting even zooplankton or Daphnia meals for meal production **(Naylor *et al*., 2009)**.

CONCLUSION

The addition of plankton mixture improved the growth rates, feed conversion ratio and survival rates of *P. vannamei* larvae, where the highest increase in weight was recorded in the larvae in which plankton replaced the fish meal by 50%, followed by 75%, then 25%. While for the experiment of substitution of daphnia powder (as one of the cultivated plankton species), the best growth and survival rates were recorded in those fed with diets with a replacement value was 75%, followed by 50% and then 25%. Growth and survival rates result for the larvae fed with conventional feed came at the last position in both trials.

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