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Impact of Dietary Protein on Total Feed Consumption, Utilization, Protein Retention, and Growth Performance of Nilem Carp (*Osteochilus vittatus*) Fingerlings

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This research aimed to observe the effect of dietary protein on the total feed consumption, feed utilization efficiency, protein retention, and growth of nilem carp (*Osteochilus vittatus*) fingerlings. Nilem carp with an average initial body weight of 2.56±0.08 g was used as trial fish. Fishes were reared in fiber ponds of (1x1x0.8) m^3. The experimental design was completely randomized, consisting of 3 treatments with 3 replications. The treatments were A, B, and C each containing 27,

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30, and 33% protein. Variables observed include total feed consumption (TFC), feed utilization efficiency (FUE), protein efficiency ratio (PER), protein retention (PR), relative growth rate (RGR), and survival rate (SR) of nilem carp (*O. vittatus*) fingerlings. At the end of this research, the results obtained are TFC A (151.05±4.84), B (113.65±1.35), and C (126.97±8.29) g; FEU A (39.76±2.07), B (53.68±1.05), and C (52.08±1.82)%; PER A (146.51±7.61), B (176.71±3.45), and C (156.77±5.46)%; PR A (19.01±1.06), B (23.65±0.46), and C (20.32±0.68)%; with RGR A (2.72±0.13), B (2.85±0.05), and C (3.05±0.09) %/day. SR values for treatments A, B, and C were found to be the same (P=.05), which is 100%. Statistical analysis showed that the rate of protein had a significant effect (P<.05) on TFC, FEU, PER, PR, and RGR. Based on the research result, it can be concluded that the best PER value was achieved by treatment B (30% protein) but the best RGR value was achieved by treatment C (33% protein).

Keywords: Feed efficiency utility; Nilem carp; Osteochilus; growth rate.

1. INTRODUCTION

Nilem carp (Osteochilus vittatus) is a freshwater species originating from Indonesia. Nilem carp are herbivorous fish. They eat periphyton and detritus in their surroundings as their nutrition sources [1]. Based on Indonesia's Ministry of Marine Affairs and Fisheries (MMAF) data, Nilem production value in 2021 compared to 2020 was raised from 29.323,24 tons to 32.854,65 tons which shows its potential as an aquaculture organism (MMAF, 2024). Nilem carp is known to be a slow grower fish because of its energy requirements and nutrient allocations [2]. Inputs of quality aquafeeds are needed to satisfy the nutrition requirements of nilem carp so that feed efficiency utility and growth can be further optimized.

Aquafeeds are an important element in aquaculture. Feeds contributed 60% of total production costs for aquaculture activities [3]. Quality aquafeeds have an optimal ratio of protein and other energy sources to achieve better efficiency and yield. Efficiently utilized Feeds are preferred in aquaculture. Nutrients of aquafeed, especially protein, are better to be customized based on the biological requirements of the fish as protein has major roles in growth promotion and cell regeneration [4].

Optimizing fish somatic development requires protein consumption at the optimum level of Energy-to-protein (E/P) ratio. An excessive or insufficient protein might negatively impact a fish's growth and feed efficiency as stated by Teles et al. [5]. A previous study showed that optimal results are achieved by a protein level of 32% with an E/P ratio of 12 [6]. Filho et al. [7] stated that Tambaqui fish (Colosoma macropomum) tends to maintain the balance of the body's energy and protein on a certain targeted level. The energy-to-protein ratios of each fish species are different. Common carp (Cyprinus carpio) require feeds with 30% protein and a ratio of E/P 8.5 kcal/g protein [8].

Based on past studies, the optimum ratio of E/P for aquafeeds is around 8 to 12 kcal/g protein [9]. While a high E/P ratio diet might result in glycogen buildup in the liver and death, a low E/P ratio feed suggests a significant protein contribution, which is indicative of a high production cost [5,10]. More in-depth study of the effects of dietary protein on Nilem carp is still needed especially for a lower E/P ratio. This study aimed to observe the effects of dietary protein in aquafeed with a ratio of E/P 9 kcal/g protein on total feed consumption, feed efficiency utility, protein retention, and growth of Nilem carp fingerlings.

2. MATERIALS AND METHODS

This study employed a completely randomized experimental design consisting of three treatments with 3 replications. This research was held from February until March 2024 at the Wet Laboratory, Aquaculture Department, Faculty of Fisheries and Marine Sciences, Diponegoro University.

2.1 Trial Fish

A total of 1.000 Nilem carp was obtained from Balai Benih Ikan Air Tawar (BBIAT) Ngrajek. These fishes were acclimated for 45 days before the experiment using 12 fiber ponds of (1 x 1 x 1) m3. The rearing ponds of stockfish were provided with aeration. At the beginning of the experiment, the trial fish were measured. The trial fishes were Nilem carp with an average initial body length of 5.9±0.13 cm and an average initial body weight of 2.56±0.08 g.

Nine fiber ponds of (1 x 1 x 1) m3 with a 40 cm water height were used to rear the trial fish. Aeration was provided for 24 hours. The trial fish was stocked at 50 fish/m3 for each pond [11] so each pond contains a total of 20 fishes. The fish was fed with at satiation method three times a day at 8.00, 12.00, and 16.00. Water quality parameters were measured twice a day. The fish's weight was measured at the beginning and end of the research.

2.2 Experimental Diets

Feed formulation was based on Niagara et al. [6] which tested feeds with dietary protein of 28, 30, and 32% and E/P ratio of 12 and 14 kcal/g protein and stated that the optimal level of protein for Nilem carp is 32% with E/P ratio of 12 kcal/g protein. The formulated diets in this study were named A, B, and C each with dietary protein of 27, 30, and 33% with an E/P ratio of 9 kcal/g protein (Table 1). The major sources of protein in the diets were fish meal, soybean meal, and corn gluten meal. Pollard, rice bran meal, and wheat flour were used as carbohydrate sources. Squid oil and corn oil were used as sources of lipids. Mineral and vitamin mixes were added to the diets. The wheat flour also served as the binder. Initially, the ingredients were measured and mixed thoroughly. The lipid source was then added dropwise and mixed thoroughly in a mixer. Water was added to the mixed compound for 25% of the compound weight. The diets were extruded and dried under the sunlight until dry. The feeds were crushed into small pieces and shieved to facilitate consumption by the fish. All of the diets were analyzed for the proximate composition at Saraswanti Indo Genetech Laboratory, Bogor.

2.3 Observed Variables

The variables observed were total feed consumption (TFC), protein intake, crude fiber intake, feed efficiency utilization (FUE), protein efficiency ratio (PER), protein retention (PR), relative growth rate (RGR), and survival rate (SR). The variables observed were analyzed to determine how dietary protein affects the growth of the experimental fishes.

Total Feed Consumption (TFC)
TFC = Initial feed weight – Leftover feed weight
Protein Intake (PI)
PI= Feed consumption x Feed Protein content

Crude Fiber Intake (CFI)

CFI= Feed consumption x Feed crude fiber content

Feed Utilization Efficiency (FUE)

$$\text{FUE}=\frac{\text{Initial fish weight-Initial fish weight}}{\text{Feed consumption}}\times 100\%$$

Protein Efficiency Ratio (PER)

$$\text{PER}=\frac{\text{Final fish weight - Initial fish weight}}{\text{Protein intake}}\text{x}100\ \%$$

Protein Retention (PR)

$$\text{PR}=\frac{\text{Final weight of fish protein - Initial weight of fish protein}}{\text{Feed consumption x Protein content of experimental feed}}\text{x}100\ \%$$

Relative Growth Rate (RGR)

$$\text{RGR}=\frac{\text{Final fish weight-Initial fish weight}}{\text{Initial fish weight x days of experiment}}\text{x}100\%$$

Survival Rate (SR)

$$\text{SR}=\frac{\text{Initial fish count}}{\text{Final fish count}}\text{x}100\ \%$$

3. RESULTS AND DISCUSSION

3.1 Results

Statistical analysis results showed that the best value for TFC was found in treatment A (27% protein feed) with a total feed consumption of 151.05±4.84 g. The best result for FUE was achieved by treatment B (30% protein feed) and C (33% protein feed) with feed utilization values of 53.68±1.05 and 52.08±1.82 %. The best results for PER and PR were found to be in treatment B with values of 176.71±3.45% and 23.65±0.46%. The highest RGR was achieved by treatment C with a value of 3.05%/day, respectively (Table 2). The value of SR for all treatments was found to be the same.

The water parameters measured were temperature, pH, and dissolved oxygen (DO). The water temperature ranged from 25.8-28ºC in the morning and 25.2-28.4ºC in the afternoon. The pH level during the experiment ranged from 7.2-7.8 in the morning and 7.2-7.8 in the afternoon. Dissolved oxygen measurement ranged from 6.4-7.2 mg/l in the morning and 5.9-7 in the afternoon.

Table 1. Percentage (dry weight basis) and proximate analysis (%) of the formulated diets

Ingredients	Diets		
	A	B	C
Fish meal	20.89	25.06	29.25
Soybean meal	7.50	10.00	12.00
Corn gluten meal	7.00	10.00	13.00
Rice bran meal	32.61	17.80	1.60
Pollard	13.00	18.14	27.15
Wheat flour	10.00	10.00	10.00
Squid oil	3.00	3.00	3.00
Corn oil	3.00	3.00	3.00
Premix	3.00	3.00	3.00
TOTAL (g)	100	100	100
Proximate composition			
Protein[1)]	27.14	30.38	33.22
NFE	40.07	48.46	36.30
Lipid[1)]	8.34	8.71	9.22
Crude Fiber[1)]	12.61	3.54	9.55
Ash[1)]	11.84	8.90	11.70
Energy (kcal/g)[2)]	263.53	298.95	282.63
E/P ratio	9.71	9.84	8.51

Notes:
[1)]Proximate analysis of Saraswanti Indo Genetech Laboratory, Bogor.
[2)]Based on the Digestible Energy (DE) assumption for tilapia with the assumption for protein = 3.5 kcal/g; lipid = 9.8 kcal/g; and NFE = 2.5 kcal/g (Wilson, [12] in Subandiyono et al., [13]
NFE: Nitrogen Free Extract

Table 2. Performances of the Experimental Nilem Carp (*Osteochilus vittatus*) Fed with Experimental Diets

Biological	Experimental Feeds		
Variables	**A (27% protein)**	**B (30% protein)**	**C (33% protein)**
TFC (g)	151.05±4.74^{c}	113.65±1.35^{a}	126.97±8.29^{b}
PI (g)	40.99±0.55^{b}	34.53±0.24^{a}	42.18±1.68^{b}
CFI (g)	19.05±0.26^{c}	4.02±0.03^{a}	12.13±0.48^{b}
FUE (%)	39.76±2.07^{a}	53.68±1.05^{b}	52.08±1.82^{b}
PER (%)	146.51±7.61^{a}	176.71±3.45^{b}	156.77±5.46^{a}
PR (%)	19.01±1.06^{a}	23.65±0.46^{b}	20.32±0.68^{a}
RGR (%/day)	2.72±0.13^{a}	2.85±0.05^{a}	3.05±0.09^{b}
SR (%)	100.00±0.00	100.00±0.00	100.00±0.00

Note: Values with the same superscript in the row are not significantly different (P = .05).

3.2 Discussion

The dietary protein of aquafeed had a significant effect on total feed consumption (TFC) (P < .05). Table 2 shows that the highest TFC was achieved by treatment A (151.05±4.74c). One of the theories in fish nutrition states that fish will consume feeds continuously until their energy requirement is met [4]. However, there was an anomaly in total feed consumption especially in treatment A. It was deduced that the high value of feed consumption was due to crude fiber content in the diets. Diets containing high levels of crude fiber might cause an accelerated intestinal passing rate which could reduce absorption time for consumed feeds, which in turn made the fish look for feed to satisfy their energy requirement [12].

Differences in protein content of each aquafeed had a significant effect on feed utilization efficiency (P<.05) with the values ranging from 39.76±2.07 (treatment A) to 53.68±1.05 % (treatment B). Treatments B and C showed a high level of feed utilization efficiencies compared to treatment A. In Khan and Maqbool [14] common carp was fed with feeds with protein content ranging from 25% to 50% and it was found that there was a significant decrease in feed conversion ratio (FCR) with the optimum protein level of 40% protein content which indicates feed efficiency can be improved when fish are fed with higher protein levels until the optimum level. Lower feed efficiency in fish fed with lower protein levels might be due to less availability of protein for synthesis which affected the fish's metabolic activities and resulted in poor growth (Ahmed and Ahmad, 2020). Furthermore, high level of crude fibers intake also hinder the digestibilities of nutrients in aquafeed as crude fibers are not digestible for fish [15,16]. Handajani (2021) stated that an amount of over 5% crude fiber in aquafeed might negatively impact nutrient digestibility, thus aquafeed of treatment A and C's feed efficiency potential were constrained due to high levels of crude fiber.

Protein efficiency ratios were significantly affected by differences in protein content (P<.05). The results ranged from 146.51±0.08 (treatment A) to 176.71±0.04% (treatment B). The best result for PER was achieved by treatment B, as shown in Table 2. Wilson [12] stated that herbivorous fish have high α-amylase activities to digest carbohydrates. The experimental diet in treatment B had a higher level of carbohydrate content than other treatments; hence energy requirements could be satisfied and protein could be maximized to promote growth. When the energy requirements of a fish are not met it will use protein as an energy substrate in gluconeogenesis, this process could reduce the value of feed efficiency [17,5].

The result of the experiment showed that dietary protein influenced protein retention value (P<.05). Treatment B had a high ratio between energy and protein content so the energy requirement needed for maintenance could be satisfied by non-protein sources maximizing protein for body deposition. Konnert et al. [18] stated that a feed's balanced carbohydrate and lipid content could spare amino acids from the catabolism process so that protein consumed by the fish could be maximized for body protein synthesis. Treatment B indicated protein-sparing activities as it showed better feed utilization despite low protein consumption [19]. As herbivorous fish, nilem carp has a high capacity for carbohydrate utilization, it was related to its insulin receptors in nilem carp's muscles and microbe activities in its intestine [20,17,4].

The growth of nilem carp was significantly influenced by the protein content of aquafeed (P<.05). Protein is a building block for cell regeneration and is an essential element. It was alleged that protein consumption influences the growth rate of nilem carp. Even though treatment B had high feed utilization efficiencies, fish in treatment B consumed a lower amount of protein. In contrast, treatment C showed a high level of feed utilization efficiencies and consumed a high amount of protein, increasing the amount of amino acid available to maximize deposition. Fishes use amino acids for their growth and tissue regeneration [21,22].

The survival rate for every treatment was the same (P=.05), which is 100%. The experimental diets given to the trial fishes didn't affect the survival rate. The minimum energy requirement of nilem carp must have been satisfied as it is needed to maintain life [17]. Higher protein content can lead to a higher rate of ammonia release due to deamination and catabolism of amino acids [23]. However, it was alleged that the ammonia level of every treatment in this study was at a tolerable level.

4. CONCLUSION

Based on the research result, it can be concluded that dietary protein in aquafeed has a significant effect on total feed consumption, feed utilization efficiency, protein efficiency ratio, protein retention, and relative growth rate. The best protein efficiency ratio value was achieved by treatment B (30% protein) but the best relative growth rate value was achieved by treatment C (33% protein). For future work, feed formulation for Nilem with an E/P ratio between 8.51 to 9.84 can be researched.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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