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Effects of Different Types of Feed on Domesticating the Wild Betta Fish *Betta rubra* Perugia, 1893

Fazril Saputra[1]*, Zulfadhli[1], Muhammad Arif Nasution[2], Ahmad Fahrul Syarif[3], Maftuch[4]
[1]Department of Aquaculture, Teuku Umar University, Aceh, Indonesia
[2]Department of Aquatic Resources, Teuku Umar University, Aceh, Indonesia
[3]Department of Aquaculture, Bangka Belitung University, Bangka Belitung, Indonesia
[4]Department of Aquaculture, Brawijaya University, East Java, Indonesia
***Corresponding Author: fazrilsaputra@utu.ac.id**

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ABSTRACT

Betta rubra is an ornamental fish endemic to Aceh Province, exhibiting significant developmental potential. This fish possesses a significant market value. Moreover, it presents challenges for domestication and exhibits slow growth rates. This research evaluated the growth performance, histological structure of gut villi, and growth patterns of *B. rubra* fish subjected to four distinct types of differences in feed for domestication purposes. The experimental design utilized a completely randomized approach, comprising four treatments and three replications, involving 120 fish with an average initial length of 3.325 ± 0.017 =cm and an average initial weight of 0.338 ± 0.007 grams. The treatments consisted of commercial pellets (P0), *Tubifex* sp. (P1), *Daphnia* sp. (P2), and *Artemia* sp. (P3), administered over 50 days. This research examined the parameters of growth performance, histology of gut villi, and growth patterns in *B. rubra* fish. The growth performance data were analyzed using the analysis of variance (ANOVA) in SPSS version 25.0, applying a 95% confidence interval. Treatments demonstrating significant differences underwent further evaluation through the Duncan test. The histology of gut villi and growth pattern data were analyzed using descriptive methods. The findings demonstrated that the provision of *Tubifex* sp. significantly influenced ($P<0.05$) the growth performance of *B. rubra* fish. *B. rubra* fish-fed *Tubifex* sp. (P1) exhibited the highest average values for both villi length and width of gut villi. Commercial pellet feed for fish (P0) and *Daphnia* sp. (P2) exhibited a negative allometric growth pattern, whereas fish-fed *Tubifex* sp. (P1) and *Artemia* sp. (P3) showed a positive allometric growth pattern. In conclusion, the provision of *Tubifex* sp. (P1) resulted in optimal growth performance and the highest average measurements of gut villi length and width in *B. rubra* fish. Variations in feed treatments resulted in distinct growth patterns of *B. rubra* fish.

INTRODUCTION

Betta rubra is an endemic ornamental fish species native to Aceh Province. **(Hayuningtyas *et al.*, 2021)**. This fish has high economic value and is of an export quality. Reports by **Permana *et al.* (2020)** and **Henry (2024)** noted that *B. rubra* fish per pair abroad in Indonesia are valued at $ 54.95, and reports by **Saputra *et al.* (2024a,**

2024b) in Indonesia elucidated that the *B. rubra* fish is valued at a price range of IDR 150.000-IDR 250.000 per pair. The high demand makes this ornamental betta fish increasingly challenged in its habitat, and it is threatened with extinction due to increasing fishing in addition to deforestation and anthropogenic land conversion **(Nur *et al*., 2020; Nur *et al*., 2022)**. Based on data from the IUCN Red List, the status of *B. rubra* fish is endangered (EN) or threatened **(Low, 2019; Pribadi *et al*., 2024)**. Domestication measures are needed to prevent the extinction of this endemic ornamental betta fish species in nature. There are three stages of fish domestication: stage 1 is able to live, stage 2 can grow, and stage 3 is reproducing in a controlled environment **(Effendi, 2004)**.

Domestication of *B. rubra* fish must be carried out immediately because it is very worrying **(Permana *et al*., 2020)**. Domestication of *B. rubra* fish has begun, but the results have not been satisfactory. *B. rubra* fish can live in controlled containers, but their growth is slow **(Saputra *et al*., 2024a)**. An effort is needed so that *B. rubra* fish can grow optimally in controlled containers by providing natural food. Research by **Marcelo *et al*. (2019)** revealed that giving Artemia to *Betta splendens* fish can maximize growth. Research by **Iskandar *et al*. (2024)** provided natural silkworms as food that can increase the growth of *Betta channoides* fish. **Thongprajukaew *el al.* (2019)** explained that mosquito larvae in both dry and wet forms are suitable for maintaining *Betta splendens* fish. **Mishbahuddin *et al*. (2024)** reported that giving natural *Tubifex* sp. food to fish *(Betta splendens)* can increase growth. Providing natural food (*Tubifex* sp.) can increase the growth of *Betta* sp. fish **(Iqbal *et al*., 2023)**. Given the numerous benefits of natural feed, research is needed on the provision of various types of natural feed to evaluate the growth performance, gut villi histology, and growth patterns of *B. rubra* fish in the context of domestication.

MATERIALS AND METHODS

Place and time of research

The study was conducted at the Mathematics and Natural Sciences Laboratory and the Aquaculture System and Environment Laboratory, part of the Faculty of Fisheries and Marine Sciences, Teuku Umar University. Fish were reared for 50 days from August to October 2024, and their weight and length were measured every ten days.

Research design

Four treatments with three replications each were used in this experimentally based investigation. Commercial feed (P0), *Tubifex* sp. (P1), *Daphnia* sp. (P2), and *Artemia* sp. (P3) were among the treatments.

Research fish maintenance procedures

This study utilized 120 fish, with 10 allocated to each treatment group. The mean initial length of the fish was 3.325 ± 0.0173cm, and the mean starting weight was 0.338 ±

0.007 grams. The instrument employed for measuring length was a Digital Caliper. In contrast, the device utilized for weighing the fish was a Joil digital scale, with a capacity of 500 grams and a precision of 0.01 grams. The fish were housed in a 10-liter aquarium with a stocking density of one fish per liter. Feeding was conducted at ad libitum. Feed checks occured daily at 08:00 and 17:00 (Western Indonesian Time). The fish's length and weight were measured every 10 days. No water alterations were implemented in this study; only the supplementation of deficient water was performed due to the utilization of a recirculating system.

Test parameters

Growth performance indicators like length gain (LG), weight gain (WG), specific growth rate (SGR), and survival rate (SR) were among the parameters assessed in the *B. rubra* fish study. Data were gathered to examine the growth parameters of *B. rubra* every 10 days. Data gathering involved measuring the length and weight of ten fish. The measured length of the fish was the total length. This length is measured from the fish's head's anterior tip to the tail fin's posterior point. The measurement equipment employed was a vernier caliper with an accuracy of up to millimeters (mm). The weight of the fish was measured using a digital scale with an accuracy of 0.01 grams. Test parameters, including survival, length increase, and weight increase, were assessed every 10 days.

The gut histology preparation followed the established histological procedures described by **Humason (1979)**, which comprised sampling, fixation, dehydration, paraffin infiltration, sectioning, and staining. After the *B. rubra* maintenance phase under different feeding regimes, one fish from each experimental group was randomly selected for dissection. The intestines were preserved in a buffered neutral formalin (BNF) jar. Dehydration was accomplished by immersing the tissue in sequential alcohol solutions (80%, 90%, 95%) before utilizing absolute alcohol. Paraffin infiltration was conducted utilizing an embedding center apparatus, and the paraffin blocks were sectioned into five-micron-thick slices with a microtome. The staining procedure involved soaking the tissue in hematoxylin for seven minutes, succeeded by eosin for three minutes. The gut tissue architecture was subsequently analyzed using a microscope fitted with a digital camera **(Zulfahmi *et al*., 2022)**.

Growth performance

The growth performance metrics encompassed the length gain (LG), weight gain (WG), specified growth rate (SGR), and survival rate (SR).

1. Length gain (LG) was calculated using the formula provided by **Saputra *et al*. (2016)**:

$$Lg = Lt - L0$$

Note: LG = length gain (cm); Lt = average body length of the fish after the experiment (cm); and L0 = average body length of the fish at the commencement of the experiment (cm).

2. Weight gain (WG) was calculated using the subsequent formula of **Saputra *et al*. (2016)**:

$$WG = Wt – W0$$

Note: WG = weight gain (grams); Wt = final average body weight of the fish after the experiment (grams); and W0 = initial average body weight of the fish at the commencement of the experiment (grams).

3. The specific growth rate (SGR) was determined using the formula provided by **Zonneveld *et al*. (1991)**:

$$SGR = (Ln\ Wt – Ln\ W0)/\ t \times 100\%$$

Note: SGR = specific growth rate (%); Ln Wt = mean weight after the study (grams); and Ln W0 = mean weight at the commencement of the study (grams), t = duration of the experiment in days.

4. Survival rate (SR) was calculated using the subsequent formula of **Saputra and Mahendra (2019)**:

$$SR = Nt/\ No \times 100\%$$

Note: SR = Survival Rate (%); Nt = Total Fish at Experiment's Conclusion; and No = Total Fish at Experiment's Initiation.

Histology of gut villi

The mean height and width of the villi across several treatments were determined using the subsequent equation **(German & Horn, 2006)**:

$$TRV = \frac{T_{Vlg} + T_{Vrg} + T_{Vug} + T_{Vbg}}{4}$$

$$LRV = \frac{L_{Vlg} + L_{Vrg} + L_{Vug} + L_{Vbg}}{4}$$

Note: TRV represents the average length of gut villi (µm); LRV denotes the average width of gut villi (µm); TVlg indicates the length of the left gut villi (µm), TVrg refers to the length of the right gut villi (µm); TVug signifies the length of the upper gut villi (µm); TVbg pertains to the length of the bottom gut villi (µm); LVlg represents the width of the left gut villi (µm); LVrg denotes the width of the right gut villi (µm); LVug indicates the width of the upper gut villi (µm); and LVbg refers to the width of the bottom gut villi (µm).

Growth pattern

Length-weight relationship

1. The equation utilized to ascertain the length-weight relationship was:

$$W = aL^b$$

Where, W = body weight (grams); L = body length (cm); and a and b are constants **(Ayoade & Ikulala, 2007)**.

2. Condition factor

$$K = W/W^*$$

Note: K signifies the condition factor; W represents the fish weight in grams; W* specifies the computed weight based on the length-weight connection **(Ragheb, 2023)**.

Water quality parameters

The evaluated water quality parameters include temperature, pH, total dissolved solids (TDS), dissolved oxygen (DO), ammonia, nitrate, and nitrite. During the maintenance phase, these parameters were measured every ten days post-sampling. The instruments employed for water quality assessment were as follows: a thermometer for temperature; a pH meter for pH; a TDS meter for total dissolved solids; a DO meter for dissolved oxygen; and a spectrophotometer for ammonia, nitrate, and nitrite measurements.

Statistical analysis

The growth performance data for *B. rubra* fish were evaluated using a variance analysis (ANOVA) test performed with SPSS version 25.0, employing a 95% confidence interval. Treatments exhibiting significant differences were subjected to an additional analysis using the Duncan test. The histology data on gut villi and the growth patterns of *B. rubra* were studied descriptively. The findings were displayed in tabular and graphical representations.

RESULTS

Growth performance

The growth performance parameters of *B. rubra*, fed with various feeds during the experiment, are summarized in Table (1). The results indicated that *Tubifex* sp. (P1) treatment yielded the highest length gain (LG), weight gain (WG), and specific growth rate (SGR). The treatment with *Tubifex* sp. (P1) exhibited a statistically significant increase ($P<0.05$) compared to the other treatments. The highest survival rate (SR) data were observed in the *Daphnia* sp. (P2) treatment. The treatment with *Daphnia* sp. (P2) exhibited a significantly higher effect ($P<0.05$) compared to both the commercial pellet (P0) and *Tubifex* sp. (P1).

Table 1. Growth and survival rates of *B. rubra* fish subjected to distinct diet regimens over 50 days

Parameter	P0 (Commercial pellet)	P1 (*Tubifex* sp.)	P2 (*Daphnia* sp.)	P3 (*Artemia* sp.)
Initial length (cm)	3.333±0.098	3.343±0.040	3.303±0.040	3.320±0.075
Final length (cm)	4.140±0.192	4.340±0.163	3.819±0.142	4.079±0.182
Initial weight (gram)	0.343±0.022	0.346±0.012	0.330±0.006	0.334±0.021
Final weight (gram)	0.542±0.089	0.759±0.085	0.522±0.034	0.666±0.124
Length gain (cm)	$0.807±0.246^{ab}$	$0.997±0.203^{b}$	$0.516±0.143^{a}$	$0.759±0.254^{ab}$
Weight gain (gram)	$0.199±0.075^{a}$	$0.413±0.081^{b}$	$0.191±0.039^{a}$	$0.332±0.144^{ab}$
Specific growth rate (%/day)	$0.961±0.306^{a}$	$1.564±0.300^{b}$	$0.991±0.118^{a}$	$1.359±0.524^{ab}$
Survival rate (%)	$70.00±10.00^{a}$	$53.33±5.77^{b}$	$96.67±5.77^{c}$	$93.33±5.77^{c}$

Note: Different superscript letters in the same row show a significant difference ($P<0.05$).

Histology of gut villi

At the study's conclusion, the dimensions of the fish gut villi were quantified for each treatment group. The measurements of the villi in *B. rubra* fish are depicted in Figs. (1, 2). The results demonstrate that the *Tubifex* sp. (P1) treatment produced the fish gut villi's most significant length and width.

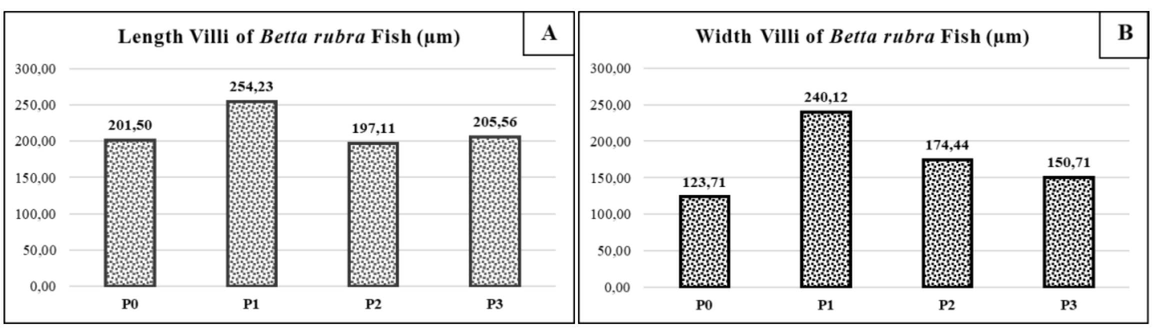

Fig. 1. The average value of villus length (A) and villus width (B) of *B. rubra* fish fed different test feeds for 50 days

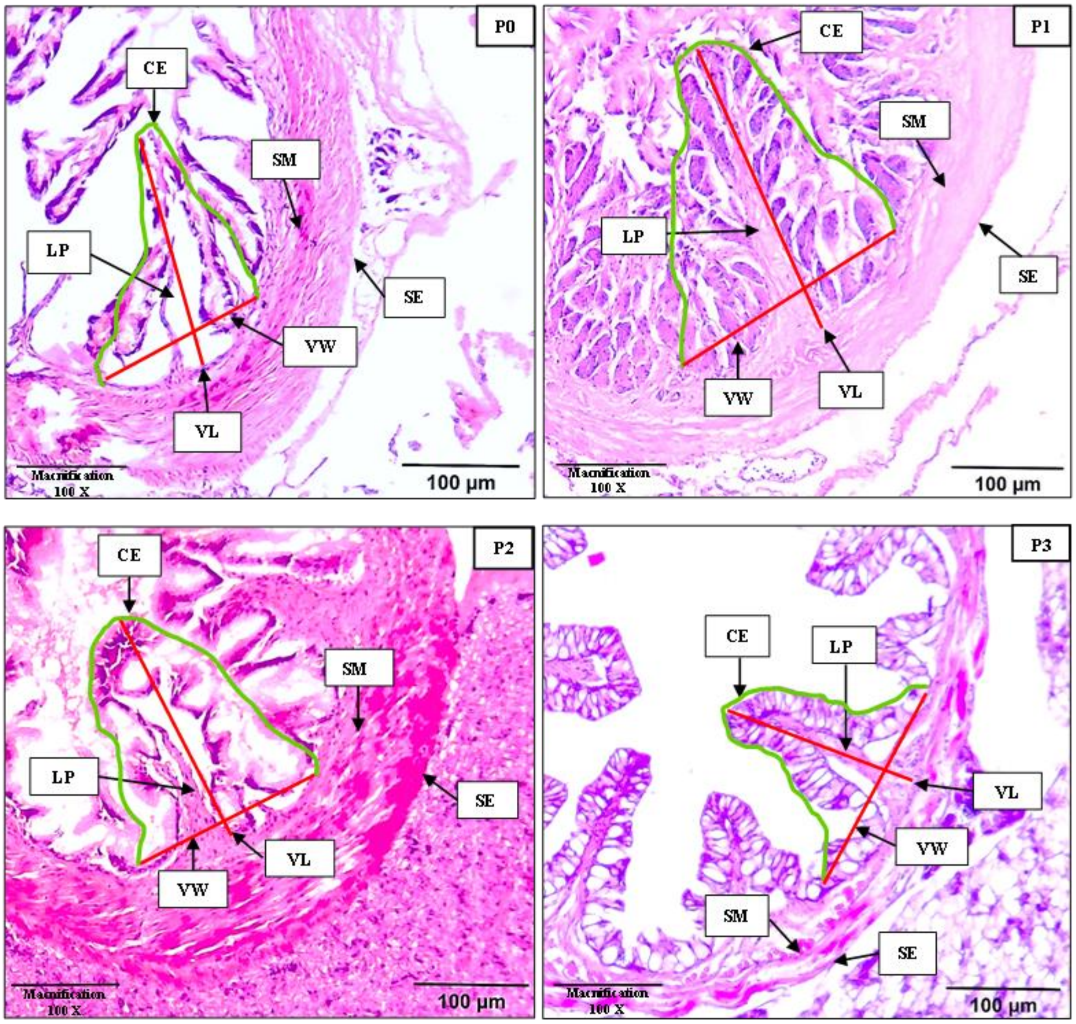

Fig. 2. Histological structure of the gut villi in *B. rubra*: Commercial feed (P0), *Tubifex* sp. (P1), *Daphnia* sp. (P2), and *Artemia* sp. (P3). SE: serous layer, SM: submucosal layer, LP: lamina propria, VL: villi length, CE: columnar epithelium, VW: villi width. Scale bar = 100 µm, magnification 100X

Growth pattern

Length-weight relationship

During the investigation, a total of 120 *B. rubra* specimens were measured. The mean initial length of these fish was 3.325 ± 0.017cm, and the mean starting weight was 0.338±0.007 grams. The mean ultimate length documented was 4.094 ± 0.215cm, and the mean end weight was 0.622 ± 0.111 grams. The regression coefficient (b) for the fish subjected to commercial feed treatment (P0) was 2.8137, while for the *Daphnia* sp. treatment (P2), it was 2.7461. Both P0 and P2 had regression coefficient values (b) below

3 (b<3), signifying that fish development under these treatments was negatively allometric. The regression coefficient for fish given *Tubifex* sp. (P1) was 4.2029, while for those fed *Artemia* sp. (P3), it was 3.7313, both exceeding 3 (b>3). This indicates that fish growth in treatments P1 and P3 demonstrated positive allometry.

The length-weight connection for *B. rubra* showed a substantial correlation (R^2) across all treatments. The length-weight connection had correlation coefficients (R^2) of 0.8896 for P0, 0.8591 for P1, 0.5795 for P2, and 0.7857 for P3. The R^2 values ranged from 0.5795 to 0.8896, indicating a connection between fish length and weight of 57.95% to 88.96%. Fig. (3) presents the analysis of the length-weight relationship.

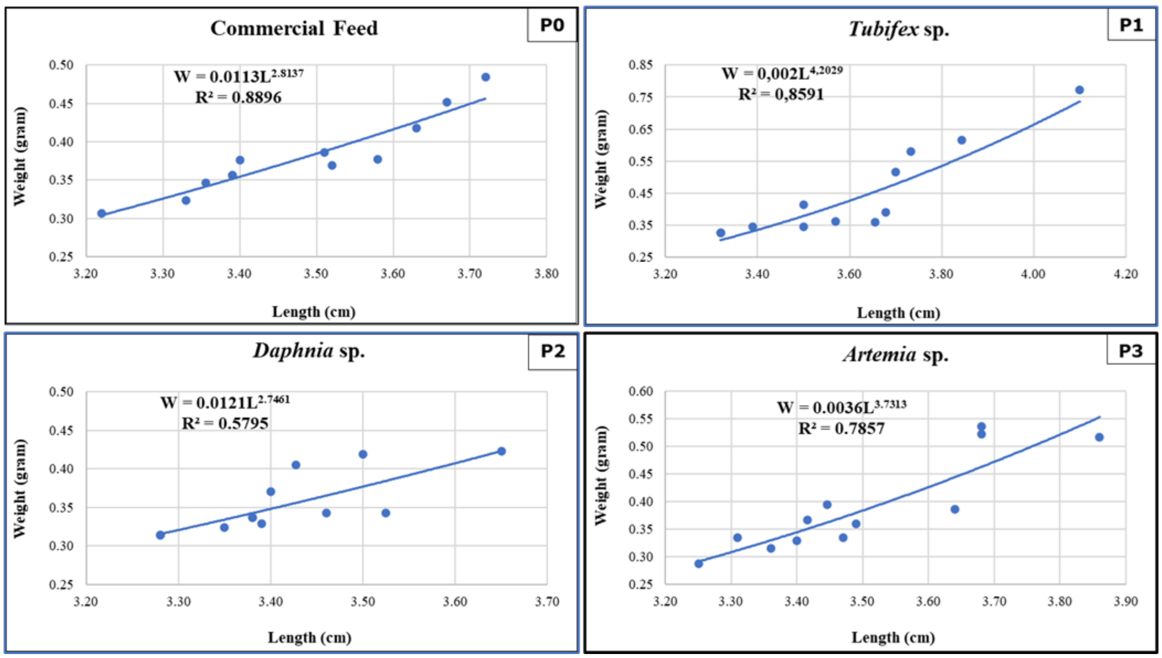

Fig. 3. Correlation between length and weight of *B. rubra* specimens maintained for 50 days

Condition factor

Maintenance of *B. rubra* fish for 50 days with different feeding resulted in similar conditions between treatments. The mean condition factor for commercial feed treatment (P0) was 1.003±0.042, *Tubifex* sp. treatment (P1) was 0.9853±0.117, *Daphnia* sp. treatment (P2) was 1.0008±0.070, and *Artemia* sp. treatment (P3) was 0.9986±0.093. The variation in feeding was not statistically significant ($P>0.05$) regarding the condition factor of *B. rubra* fish. Fig. (4) illustrates the impact of various meals on the condition factor of fish.

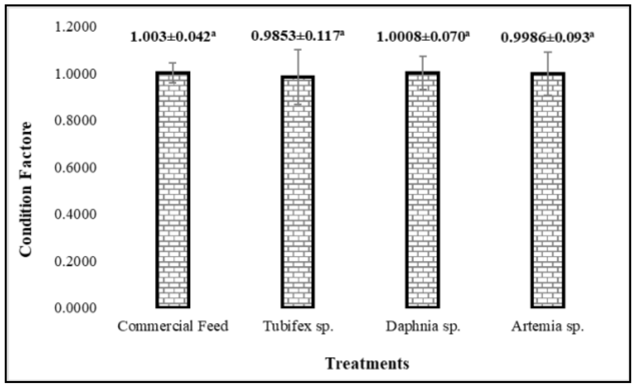

Fig. 4. Condition variables of *B. rubra* fish subjected to various meal types over 50 days

Note: Identical superscript letters within the same row denote the absence of significant differences (P>0.05).

Water quality

Water quality evaluations for the preservation of *B. rubra* fish encompassed measuring temperature, pH, total dissolved solids (TDS), dissolved oxygen (DO), ammonia, nitrate, and nitrite. Table (2) presents the results of these water quality measurements. The findings indicate that the water quality during the maintenance of *B. rubra* stayed within the ideal range for their survival.

Table 2. Range of water quality parameters throughout the study of *B. rubra* fish

Parameter	Treatments				Normal range
	P0	P1	P2	P3	
Temperature (°C)	28.2-29.9	27.8-29.9	29.6-30.2	28.3-30.1	28-32[1]
pH	8.7-9.2	8.7-8.9	8.7-8.9	8.4-8.7	5-9[1]
Dissolved oxygen (mg L^{-1})	8.63-8.93	7.52-8.91	7.55-8.55	8.26-8.74	8.5-9.1[2]
Total dissolved solids (mg L^{-1})	184-219	177-195	155-205	180-223	≤200[3]
Ammonia (mg L^{-1})	0.023-0.36	0.05-0.06	0.09-0.12	0.07-0.09	0.005-0.035[4]
Nitrite (mg L^{-1})	0.191-0.808	0.188-1.847	0.177-1.479	0.065-1.847	≤343.6[4]
Nitrate (mg L^{-1})	11.6-29.6	30.2-49.5	6.3-29.8	23.0-15.9	≤100[5]

Note: [1]**Lichak *et al.* (2022)**; [2]**Nur *et al.* (2022)**; [3]**Somantri *et al.* (2022)**; [4]**Shams *et al*. (2024)**; and [5]**Stow (2024)**.

DISCUSSION

Growth performance

The results indicated that various types of feed influenced the growth performance of *B. rubra* fish. The fish were provided with commercial feed and live feed over a period of 50 days. The growth performance observed in this study included length gain (LG), weight gain (WG), specific growth rate (SGR), and survival rate (SR). The best LG, WG, and SGR were found in the *Tubifex* sp. (P1) treatment. In the *Tubifex* sp. (P1) treatment, the LG value was 0.997±0.203cm, the WG value was 0.413±0.081 grams, and the SGR value was 1.564±0.300 %/day. This is because *Tubifex* sp. has high essential nutrients such as protein, which fish need very much. Giving *Tubifex* sp. makes fish's growth performance work well. *Tubifex* sp., which has a protein content of up to 64%, is an alternative for the development of larval stages in farmed fish **(Safrina *et al*., 2015)**. The protein content of *Tubifex* sp. can reach 50-60% of its dry weight, which is very important for muscle and tissue growth in fish. This protein consists of various essential amino acids needed for protein synthesis in fish, supports the formation of new tissue, and repairs damaged tissue **(Mandal *et al*., 2012; Amrullah *et al*., 2023; Simangunsong *et al*., 2024)**.

The survival rate (SR) of *B. rubra* in the *Tubifex* sp. treatment (P1) yielded the lowest value. This is believed to result from the continuous availability of natural *Tubifex* sp. meal provided ad libitum to the test fish in the treatment container. *Tubifex* sp. is highly susceptible to mortality in the maintenance container; thus, when *Tubifex* sp. perishes, water quality deteriorates. *Tubifex* sp. will perish when temperature, density, or nourishment are absent in the cultivation container. *Tubifex* sp. is challenging to acclimate in containers that do not replicate its natural habitat **(Oplinger *et al*., 2011; Simangunsong *et al*., 2023)**. Nonetheless, the outcomes of the SR treatment of *Tubifex* sp. (P1) might still be favorable. **Arifaldianzah *et al*. (2022)** classified a survival rate beyond 50% as favorable, 30-50% as moderate, and below 30% as perilous. The adaptation of fish to food and environment, population density, health state, and water quality that facilitate fish growth performance all contribute to survival rates **(Kautsar *et al*., 2020)**.

The highest survival rates observed in this study were in the treatments involving *Daphnia* sp. (P2) and *Artemia* sp. (P3). The observed phenomenon is likely due to the smaller size of *Daphnia* sp. and *Artemia* sp., which aligns well with the mouth size of *B. rubra* fish. According to **Akter *et al*. (2024)**, farmed fish consume smaller feed sizes more rapidly than larger ones. Furthermore, *Daphnia* sp. and *Artemia* sp. demonstrate a greater capacity for adaptation to conditioned environments. *Daphnia* sp. and *Artemia* sp. are common test indicators in laboratory settings **(Vega *et al*., 2020)**. *Daphnia* sp. serves as a crucial indicator species for assessing environmental stress. *Daphnia* sp. is a prominent model organism in ecotoxicity and standard chemical testing **(Reilly *et al*.,**

2023). An advantage of *Artemia* sp. compared to other natural aquaculture feeds is its cyst form availability, enabling its use whenever required. Furthermore, *Artemia* sp. can flourish in various high salt concentrations while existing as plankton **(Bahri *et al*., 2021)**.

Histology of gut villi

Gut morphology is associated with digestive efficiency and the degree of nutrient absorption from ingested feed **(Zulfahmi *et al*., 2019)**. Figs. (1, 2) illustrate the effects of diet on the length and width of the villi in *B. rubra* fish over a 50-day feeding period. The results indicate that the *Tubifex* sp. (P1) treatment exhibits the villi's most excellent length and width. The findings suggest that *Tubifex* sp. administration enhances histometric parameters in *B. rubra*, improving nutrient absorption. The histometric parameters are directly proportional to the growth performance parameters of *B. rubra*, with *Tubifex* sp. (P1) treatment yielding the most favorable results. Currently, histometric measurements of the fish gut system, such as the length and width of gut villi, are considered essential indicators for assessing the nutrient absorption rate from feed and its relationship to fish growth performance. Multiple studies indicate a positive correlation between increased lengths and widths of gut villi and improved fish growth. Smaller dimensions of the villi, specifically in length and width, are generally linked to diminished growth performance **(Zulfahmi *et al*., 2022)**.

Histologically, the gut villi of *B. rubra* fish comprise several principal components: SE: serous layer, SM: submucosal layer, LP: lamina propria, and CE: columnar epithelium (Fig. 2). All these components are detected in the gut villi of *B. rubra* fish across all treatments. The distinction in gut villi of *B. rubra* fish is solely in their dimensions. This is attributable to the diet ingested by *B. rubra* fish. Feed enhances growth performance and feed efficiency by optimizing the shape of the fish gut **(Islam *et al*., 2021)**. **Toutou *et al*. (2019)**, asserted that variations in feed content result in discrepancies in the length of the gut villi of the Nile tilapia (*Oreochromis niloticus*). Histological examination of catfish receiving high-protein feed reveals elongated villi and an increased number of goblet cells, the predominant mucus-secreting cells in the gut epithelium of fish **(Septriani *et al*., 2024)**.

Growth pattern

Length-weight relationship

The correlation coefficient (b) value distinguishes between the commercial feed treatments and the natural feed provided to *B. rubra* fish. The correlation coefficient between treatments P0 and P2 is less than 3 ($b<3$), indicating a negative allometric growth pattern for *B. rubra* fish. The correlation coefficient value for treatments P1 and P3 exceeds 3 ($b>3$), indicating a positive allometric growth pattern for *B. rubra* fish. The negative allometric growth pattern indicates that the increase in length is more pronounced relative to the increase in weight, whereas the positive allometric growth pattern suggests that the increase in weight is more pronounced relative to the increase in length **(Rinandha *et al*., 2020; Nur *et al*., 2023; Saputra *et al*., 2024c)**. The observed difference can be attributed to the specific type of feed provided to *B. rubra* fish. The composition of the feed content provided to *B. rubra* fish influences the growth pattern. **Elshaer *et al*. (2022)** presented an examination of the growth pattern of cultivated fish *Oreochromis niloticus* exhibits varying correlation coefficient (b) values in response to different feed compositions. **Zhang *et al.* (2023)** indicated that the growth pattern of Gibel Carp (*Carassius auratus* gibelio var. CAS V) is influenced by feed components (nutrition) and age. Growth patterns exhibit notable variations between fish cultivated in controlled environments and their wild counterparts. Optimal feeding and water conditions in the culture container promote favorable allometric growth in cultured rainbow and brook trout. The cultured rainbow trout and brook trout exhibit larger body sizes than their wild counterparts, which typically display negative allometric growth patterns. This phenomenon is linked to food availability and environmental conditions **(Dürrani, 2023)**. The growth pattern of *B. rubra* fish in their natural habitat exhibits a negative allometric trend **(Saputra *et al*., 2024b)**.

Condition factor

The condition factor (K) of fish indicates their physical and biological state, reflecting variations due to food availability, parasitic infections, and physiological factors **(Le Cren, 1951; Datta *et al*., 2013)**. The condition factor value for *B. rubra* in the feed differences study was established at 1, indicating optimal conditions throughout the research. When fish receive adequate nutrition for growth, the condition factor value (K) typically exceeds one, signifying optimal growth conditions **(Jisr *et al*., 2018; Ragheb, 2023; Saputra *et al*., 2024c)**. The condition factor is influenced by variables such as nutrition, sex, age, physiological state, and environmental conditions **(Morato *et al*., 2001; Effendie, 2002; Jisr *et al*., 2018; Rachmanto *et al*., 2020; Rinandha *et al*., 2020)**.

Water quality parameters

Water quality parameters during the maintenance period consistently fall within the optimal range necessary for the growth of *B. rubra* fish. **Lichak *et al*. (2022)** indicated that the optimal temperature range for *Betta* sp. fish growth is 28-32°C, with an optimal pH range of 5-9. The dissolved oxygen (DO) value of *B. rubra* during maintenance remains within the normal range. The dissolved oxygen (DO) value of *B. rubra* in its natural habitat ranges from 8.5 to 9.1mg L^{-1} **(Nur *et al*., 2022)**. The TDS value of *B. rubra* fish remains within normal parameters. The TDS value of ornamental fish is considered normal at ≤200 **(Somantri *et al*., 2022)**. During the maintenance of *B. rubra*, the ammonia, nitrite, and nitrate levels are within the acceptable ranges. The typical concentrations for ammonia range from 0.005 to 0.035mg L^{-1}, nitrite is ≤343.6mg L^{-1}, and nitrate is ≤100mg L^{-1} for *Betta* sp. **(Shams *et al*., 2024; Stow, 2024)**.

CONCLUSION

Feeding *Tubifex* sp. (P1) provided the best growth performance and the highest average value of length and width of gut villi of *B. rubra* fish. Differences in feed treatments provided differences in the growth patterns of *B. rubra* fish.

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REFERENCES

Akter, M.; Schrama, J.W.; Adhikary, U.; Alam, M.S.; Mamun-Ur-Rashid, M. and Verdegem, M. (2024). Effect of pellet-size on fish growth, feeding behaviour and natural food web in pond polyculture. Aquaculture 593:1-13. Https://doi.org/10.1016/j. aquaculture. 2024.741342'

Amrullah.; Wahidah.; Khatimah, K.; Ardiansyah.; Rosyida, E. and Taufik, I. (2023). Evaluation of feed types based on growth performance, survival, hematology, and resistance in celebes rainbow (*Marosantherina ladigesi*). Fisheries and Aquatic Sciences, 27(11):583-592. Https://doi.org/10.47853/FAS.2023.e50

Arifaldianzah.; Khaeriyah, A.; Anwar, A.; Burhanuddin.; Salam, N.I. and Saleh, M.S. (2022). Growth Rate of (*Oreochromis* sp) Saline Tilapia Seeds Cultured in Biofloc System using Fermented Vegetable Waste Feed. Torani: JFMarSci, 5(2): 118-128. Https://doi.org/10.35911/torani.v5i2.19783

Ayoade, A. A. and Ikulala, A.O.O. (2007). Length weight relationship, condition factor and stomach contents of *Hemichromis bimaculatus*, *Sarotherodon melanotheron* and *Chromidotilapia guentheri* (Perciformes: Cichlidae) in Eleiyele Lake, Southwestern Nigeria. Revista de Biologia Tropical, 55(3-4):969-977.

Bahri, A.S; Isroni, W. and Maulida, N. (2021). Hatching and harvesting techniques for Artemia cysts with different effects of salinity in the district of Situbondo, East Java. IOP Conf. Series: Earth and Environmental Science 718 (2021) 012037. Https://doi.org/10.1088/1755-1315/718/1/012037

Datta, S.N.; Kaur, V.I.; Dhawan, A. and Jassal. G. 2013 Estimation of Length-Weight Relationship and Condition Factor of Spotted Snakehead *Channa Punctata* (Bloch) Under Different Feeding Regimes. SpringerPlus, 2(436):1-5. Https://doi.org/10.1186/2193-1801-2-436

Dürrani, Ö. 2023. Do the Length-Weight Relationships and Condition Factors of Farmed Rainbow Trout, Brook, and Brown Trout Differ From Their Wild Counterparts?. Aquatic Research, 6(4), 253-259. Https://doi.org/10.3153/AR23024

Effendie, M.I. (2002). Fisheries biology, Yayasan Pustaka Nusantara, Yogyakarta.

Effendi, I. (2004). Introduction to Aquaculture, Penebar Swadaya, Jakarta.

Elshaer, F.M.; Azab, A.M. and El-Tabakh, MA.M. (2022). Effect of Replacing Fish Meal in Fish Diet with Shrimp by-Product Meal on Growth Performance, Feed Utilization, Length-Weight Relationship and Condition Factors of Nile Tilapia, *Oreochromis niloticus* (Linnaeus, 1758). International Journal of Morphology, 40(1): 261-269. Https://doi.org/10.4067/S0717-95022022000100261

German, D.P and Horn, M.H. (2006). Gut length and mass in herbivorous and carnivorous prickleback fishes (Teleostei: Stichaeidae): ontogenetic, dietary, and phylogenetic effects. Marine Biology, 148: 1123-1134. Https://doi.org/10.1007/s00227-005-0149-4

Hayuningtyas, E.P.; Kusrini, E.; Sinansari, S. and Fahmi, M.R. (2021). Genetic variation of three farmed-generat ions of *Betta rubra*, Perugia 1893 (Pisces: Osphronemidae), an endemic fish to Aceh. Jurnal Riset Akuakultur, 16(2): 71-82. Https://doi.org/10.15578/jra.16.2.2021.71-82

Henry. (2024). Rubra Complex. https://bwaquatics.com/ collections/rubra-complex.

Humason, G.L. (1979). Animal tissue techniques. Freeman Company, San Francisco, USA.

Iskandar, A.; Setiawan, W.D.; Permana, A. and Indriastuti, C.E. (2024). The Effect of Different Live Feeds on the Growth Performance of Wild Betta *Betta channoides* Fry. Journal of Vocational in Aquaculture, 1(1): 34-40. Https://doi.org/10.29244/java.v1i1.59577

Islam, S.M.; Rohani, M.F. and Shahjahan, M.D. (2021). Probiotic yeast enhances growth performance of Nile tilapia (*Oreochromis niloticus*) through morphological modifications of intestine. Aquaculture Reports 21:1-7. Https://doi.org/10.1016/j.aqrep.2021.100800

Iqbal, M.S.M. and Prayogo, and Samara, S.H. (2024). Effect of Different Natural Feeding (Blood Worm, Silk Worm, and Water Fleas) on The Growth of Betta Fish (*Betta* sp.). IOP Conf. Series: Earth and Environmental Science, 1273 (2023) 012052. Https://doi.org/10.1088/1755-1315/1273/1/012052

Jisr, N.; Younes, G.; Sukhn, C. and El-Dakdouki, M.H. 2018. Length-Weight Relationships and Relative Condition Factor of Fish Inhabiting the Marine Area of The Eastern Mediterranean City, Tripoli-Lebanon. Egyptian Journal of Aquatic Research, 44(4):299-305**.** Https://doi.org/10.1016/j.ejar.2018.11.004

Kautsar, A.; Marzuki, M. and Scabra, A.R. (2022). The effect of additional silk worm (*Tubifex* sp.) on artificial feed on the number of larva Guppy fish (*Poecilia reticulata*). IJOTA, 5(1): 33-42. Https://doi.org/10.22219/ijota.v5i1.18828

Le Cren, E. 1951. The Length-Weight Relationship and Seasonal Cycle in Gonad Weight and Condition In The Perch *(Perca fluviatilis*). British Ecological Society 20(2):201-219.

Lichak, M.R.; Barber, J.R.; Kwon, Y.M.; Francis, K.X. and Bendesky, A. (2022). Care and Use of Siamese Fighting Fish (*Betta splendens*) for Research. Comparative Medicine, 72(3): 169-180. Https://doi.org/10.30802/AALAS-CM-22-000051

Low, B. (2019). *Betta rubra*. The IUCN Red List of threatened species 2019. e.T91310582A91310586.

Mandal, S.C.; Kohli, M.P.S.; Das, P.; Singh, S.K.; Munilkumar, S.; Sarma, K. and Baruah, K. (2012). Effect of substituting live feed with formulated feed on the reproductive performance and fry survival of Siamese fighting fish, *Betta splendens* (Regan, 1910). Fish Physiol Biochem, 38:573–58. Https://doi.org/10.1007/s10695-011-9539-3

Matielo, M.D.; Gonçalves Jr, L.P.; Pereira, S.L.; Selvatici, P.D.C.; Mendonça, P.P.and Troina, C.A. (2019). Five different foods in initial development of Siamese fighting fish (*Betta splendens*). AACL Bioflux, 12(5): 1755-1761.

Mishbahuddin, M.Z; Agustini, M. and Madyowati, S.O. (2024). The Influence of Different Types Of Natural Feed Mosquito Larvae, Silkworms (*Tubifex* sp), and Water Fleas (*Daphnia* sp). Against The Growth Of Betta Fish (*Betta Splendens*) In The Maintenance Trough. AGROPRO, 2(2):270-278. Https://doi.org/10.25139/agropro.v2i2.8390

Morato, T.; Afonso, P.; Lourinho, P.; Barreiros, J.P.; Santos, R.S. and Nash, R.D.M. (2001). Length-Weight Relationships for 21 Coastal Fish Species of the Azores, North-Eastern Atlantic. Fisheries Research, 50(3):297-302. Https://doi.org/10.1016/S0165-7836(00)00215-0

Nur, F.M.; Batubara, A.S.; Eriani, K.; Tang, U.M.; Muhammadar, A.A.; Siti-Azizah, M.N; Wilkes, M.; Fadli, N.; Rizal, S and Muchlisin, Z.A. (2020). Effect of water temperature on the physiological responses in *Betta rubra*, Perugia 1893 (Pisces: Osphronemidae). International Aquatic Research, 12: 209-218. Https://doi.org/10.22034/IAR.2020.1900150.1053

Nur, F.M.; Batubara, A.S.; Fadli, N.; Rizal, S.; Siti-Azizah, M.N. and Muchlisin, Z.A. (2022). Diversity, distribution, and conservation status of *Betta* fish (Teleostei: Osphronemidae) in Aceh waters, Indonesia. The European Zoological Journal, 89(1): 142–151. Https://doi.org/10.1080/24750263.2022.2029587

Nur, M.; Tenriware. and Nasyrah, A.F.A. (2023). Length-Weight Relationship and Condition Factor of Bullet Tuna (*Auxis rochei* Risso, 1810) in The Waters of Mamuju District, West Sulawesi Province, Indonesia. Biodiversitas, 24(10):5253-5259. Https://doi.org/10.13057/biodiv/d241005

Oplinger, R.W.; Bartley, M. and Wagner, E.J. (2011). Culture of *Tubifex tubifex*: Effect of Feed Type, Ration, Temperature, and Density on Juvenile Recruitment, Production, and Adult Survival. North American Journal of Aquaculture, 73(1):68-75. Https://doi.org/10.1080/15222055.2010.549028

Permana, A.; Kusrini. E.; Priyadi, A. and Cindelaras, S. (2020). Embriogenesis and larval development of domesticated wild betta (*Betta rubra* Perugia, 1893). Jurnal Riset Akuakultur, 15(1): 19-29. Https://doi.org/10.15578/jra.15.1.2020.19-29

Priyadi, A.; Permana, A.; Kusrini, E.; Hayuningtyas, E.P.; Nur, B.; Lukman.; South, J.; Cindelaras, S.; Rohmy, S.; Ginanjar, R.; Yamin, M.; Said, D.S.; Kadarini, T. and Budi, D.S. (2023). Captive breeding of endangered betta fish, *Betta rubra*, under laboratory conditions. Fisheries and Aquatic Sciences, 27(4): 213-224. Https://doi.org/10.47853/FAS.2024.e21

Ragheb, E. (2023). Length-weight relationship and well-being factors of 33 fish species caught by gillnets from the Egyptian Mediterranean waters off Alexandria. Egyptian Journal of Aquatic Research, 49:361-367. Https://doi.org/10.1016/j.ejar.2023.01.001

Rachmanto, D.; Djumanto, D. and Setyobudi, E. 2020**.** Reproduction of Indian Mackerel Rastreliger Kanagurta (Cuvier, 1816) in Morodemak Coast Demak Regency. Jurnal Perikanan Universitas Gadjah Mada, 22(2):85-91. Https://doi.org/10. 22146 /jfs.48440

Reilly, K.; Ellis, L.A.; Davoudi, H.H.; Supian, S.; Maia, M.T.; Silva, G.H.; Guo, Z.; Martinez D.S.T and Lynch, I. (2023). *Daphnia* as a model organism to probe biological responses to nanomaterials-from individual to population effects via adverse outcome pathways. Front. Toxicol, 5:1-12. Https://doi.org/10.3389/ftox.2023.1178482

Rinandha, A.; Omar, S.B.A.; Tresnati, J.; Yanuarita, D. and Umar, M. T. (2020). Length-weight relationship and condition factors of matano medaka (*Oryzias matanensis* Aurich, 1935) in Towuti Lake, South Sulawesi, Indonesia. AACL Bioflux 13(4):1946-1954.

Safrina.; Putri, B. and Wijayanti, H. (2015). Growth of *Tubifex* sp. on Banana Peel (*Musa paradisiaca*) and Paddi Field Mud. Prosiding Seminar Nasional Swasembada Pangan, 520-525. Https://doi.org/10.25181/prosemnas.v0i0.573

Saputra. F,; Wahjuningrum, D.; Tarman, K. and Effendi, I. (2016). Utilization Of Marine Fungal Nodulisporium sp. KT29 Metabolites To Improve The Production Performance Of Marine Culture of White Shrimp. 8(2): 747-755. Https://doi.org/10.28930/jitkt.v8i2.15839

Saputra, F. and Mahendra, M. (2019). Maintenance of Local Snakehead Postlarva *Channa* sp. on Different Containers in Domestication Framework. Jurnal Iktiologi Indonesia, 19(2), 195-203. Https://doi.org/10.32491/jii.v19i2.477

Saputra, F.; Zulfadhli.; Nasution, M. A; Syarif A. F; Maftuch. and Samuki, K. (2024a). Survival and Growth of Serban Malem Fish (*Betta rubra* Perugia 1893) Result of Domestication with Different Stocking Densities. Jurnal Akuakultura, 8(1): 15-18. Https://doi.org/10.35308/ja.v8i1.9233

Saputra, F.; Zulfadhli.; Nasution, M. A; Syarif A. F; Maftuch. and Friyuanita. (2024b). Length-Weight Relationship and Condition Factors of The Endemic Serban Malem Betta Fish (*Betta rubra* Perugia 1893) In Water Canal Malem Hills, Aceh Jaya District, Aceh Province, Indonesia. Jurnal Perikanan, 14(1): 330-340. Https://doi.org/10.29303/jp.v14i1.786

Saputra, F.; Zulfadhli.; Nasution, M.A.; Syarif, A.F.; Maftuch. and Lubis, F. Length-Weight Relationship And Condition Factor of Endemic Jielabu Betta Fish (*Betta Dennisyongi* Tan, 2013) in The Water Canals of Beutong Hills, Aceh Province, Indonesia. 17(4):1560-1568.

Septriani, N.I.; Nizma, N.D.A. and Paramita, P. (2024). Unraveling The Impact of Feed Protein Content on Catfish (*Clarias* sp.) Growth, Survival, Meat Quality and Gastrointestinal Histology. 10(2): 89-102. Https://doi.org/10.19109/Biota.v10i2.19715

Shams, S.; Sahu, J.N.; Zambree, M.; Taha, A. and Karri, R.R. (2021). Impact of Indian almond leaves on aquarium water quality. IOP Conf. Series: Earth and Environmental Science, 920 (2021) 012008. Https://doi.org/10.1088/1755-1315/920/1/012008

Simangunsong, T.; Anjaini, J.; Situmorang, N. and Liu, C. (2023). The Latest Application of *Tubifex* As Live Feed In Aquaculture. Journal of Environmental Engineering & Sustainable Technology, 10(02): 112-121. Http://dx.doi.org/10.21776/ub.jeest.2023.010.02.8

Simangunsong, T.; Anjaini, J.; Soedibya, P.H.T. and Liu, C. (2024). Utilization Of Tubifex Worms As Natural Feed For Growth And Development Of Fish Larvae. Journal of Environmental Engineering & Sustainable Technology, 1(1): 33-43. Http://dx.doi.org/10.21776/ub.jeest.2024.011.01.5

Somantri, N.T; Darwin, N; Nurjaman, D.F; Hidayat, M.R and Winanti N. (2022). Sistem Monitoring Kualitas Air pada Akuarium Budidaya Ternak Ikan Guppy Menggunakan Mikrokontroler Berbasis IoT. Jurnal Teknik: Media Pengembangan Ilmu dan Aplikasi Teknik, 21(02): 144-157. Https://doi.org/10.55893/jt.vol21no2.466

Stow, C. (2024). Behavioral Effects Of Nitrate On Siamese Fighting Fish (*Betta splendens*): Female Mate Preference And Anxiety. The Honors College, University of Maine, Maine, United States.

Thongprajukaew, K.; Pettawee, S.; Muangthong, S.; Saekhow, S.; and Phromkunthong, W. (2019). Freeze-dried forms of mosquito larvae for feeding of Siamese fighting fish (*Betta splendens* Regan, 1910). Aquaculture Research, 50:296–303. Https://doi.org/10.1111/are.13897

Toutou, M.M.; Osman, A.G.M.; Farrag, M.M.S.; Badrey, A.E.A.; and Moustafa, M.A. (2019). Growth Performance, Feed Utilization And Gut Histology Of Monosex Nile Tilapia (*Oreochromis niloticus*) Fed With Varying Levels of Pomegranate (*Punica granatum*) Peel Residues. 12(1):298-309.

Vega, A.C.S.D.L.; Cruz-Alcalde, A.; Mazón, C.S.; Martí, C.B.; and Diaz-Cruz, M.S. (2020). Nano-TiO_2 Phototoxicity in Fresh and Seawater: *Daphnia magna* and *Artemia* sp. as Proxies. 13(1): 1-13. Https://doi.org/10.3390/w13010055

Zhang, H.; Xie, S.; and Wang. S. (2023). Weight-Length Relationship and Condition Factor of Gibel Carp (*Carassius auratus* gibelio var. CAS V) at Different Growth Stages and Feed Formulations. Fishes, 8(439). Https://doi.org/10.3390/fishes8090439

Zonneveld, N.; Boon, J.H.; and Huisman, E.A. (1991). Principles of fish farming. Gramedia Pustaka Utama, Jakarta.

Zulfahmi, I.; Herjayanto, M.; Batubara, A.S.; and Affandi, R. (2019). Palm Kernel Meal as a Fishfeed Ingredient For Milkfish (*Chanos Chanos*, Forskall 1755): Effect On Growth And Gut Health. Pakistan Journal of Nutrition, 18(8), 753-760. Https://doi.org/10.3923/pjn.2019.753.760

Zulfahmi, I; Audila, A.; Sari, A.N.; Nur, F.M.; Nugroho, R.A.; and Hasri, I. (2022). Anchovies (*Stolephorus* sp.) By-product Material as a Fish-feed Ingredient of Seurukan Fish (*Osteochilus vittatus*): Effect on Growth Performance and Gut Morphology. Journal of Aquaculture and Fish Health, 11(2): 255 268. Https://doi.org/10.20473/jafh. v11i2.33189