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Growth of Tilapia (*Oreochromis niloticus*) Juvenile strain Nirwana with Different Natural Feeding

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Abstract

The high cost of commercial feed in Nirwana tilapia aquaculture leads to elevated production costs and reduced profits. As a solution, the provision of natural feed is proposed as an alternative to reduce production expenses. This study aims to compare the growth of Nirwana tilapia fed with three different natural feeds: *Tubifex* sp., *Chironomus sp*. larvae, and maggots. The experiment was conducted using a completely randomized design with three replicates for each treatment. The feeding rate was 3% of the fish's body weight, administered three times a day. The parameters measured included absolute biomass, absolute length gain, daily growth rate (Specific Growth Rate, SGR), survival rate (SR), and water quality during the 30-day rearing period. The results showed that feeding Nirwana tilapia with *Tubifex* significantly increased growth compared to the control group (commercial pellets), Chironomus larvae, and maggots. The absolute biomass from *Tubifex* feeding was 5.23 ± 0.89 g, absolute length was 4.2 ± 7.8 cm, SGR was 1.52 ± 0.33%, and SR was 90%. The next highest growth was seen in Chironomus larvae, followed by maggots, with the control yielding the lowest results.

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Introduction

The Nirwana strain of tilapia is a result of selective breeding by the Wanayasa Freshwater Fish Seed Development Center (BPBIAT) in Purwakarta, West Java. This selective breeding aimed to improve the genetic quality of tilapia, which had declined due to extensive inbreeding, negatively affecting growth rates. The male F2 Nirwana tilapia from Wanayasa displayed a genetic gain of 30.4%, while the females showed a gain of 12.8% (Gustiano, 2008). This superior growth rate distinguishes the Nirwana strain from other tilapia strains, reaching 650 grams in just six months compared to 500 grams for other strains in the same period (Putri, 2018).

This growth advantage has led many fish farmers to cultivate Nirwana tilapia. However, the cost of feed remains a significant barrier to more extensive

cultivation. Feed accounts for 70-90% of total production costs, primarily due to the high protein content required, which raises prices and reduces profitability (Efrizal, 2018; Islama, 2020). Therefore, natural feed alternatives, rich in protein, are needed to substitute commercial feed and help reduce these production costs. Maggots, silkworms (*Tubifex* sp.), and bloodworms (*Chironomus sp*. larvae) have been proposed as natural feed alternatives due to their high protein content, which ranges from 37.97% to 44.58% (Indariyanti, 2018), with silkworms containing up to 57% protein.

Maggots (Hermetia illucens) are the larvae of the Black Soldier Fly and are known for being easy to cultivate and rich in protein, The average crude protein content of maggots is 414.7 g/kg (Lu et al., 2022). In addition to their high protein content, maggots and antimicrobial properties, which help increase fish resistance to bacterial infections (Amandanisa, 2020). Hermetia illucens has been observed to reduce Escherichia coli O157 (Liu et al., 2008), Salmonella enterica Typhimurium, and Listeria monocytogenes (Grisendi et al., 2022), demonstrating significant antimicrobial activity. Furthermore, antimicrobial peptides (AMPs) derived from maggots can inhibit both gram-positive and gram-negative pathogenic microbes (Diyantoro et al., 2022)."This high protein content aids in enhancing fish growth. In a study, Balashark (Balantiocheilus melanopterus) fed with maggots achieved a specific growth rate (SGR) of 6.51%, compared to 3.88% for fish fed solely with commercial pellets (Fahmi, 2009). Similarly, Betok (Anabas testudineus) showed a 35.6% increase in growth when fed maggots as supplementary feed (Torang, 2013). A 50:50 combination of maggots and commercial feed was shown to optimally increase growth rates in tilapia (Sepang, 2021).

Silkworms (*Tubifex* sp.) are also an effective natural food, easy to digest and highly nutritious, stimulating growth. *Tubifex* contains up to 57% protein, 13.30% fat, and 2.04% crude fiber (Weisman et al., 2015). Feeding silkworms has been shown to increase the absolute growth of fish like pomfret by up to 3.3950 g over 30 days (Taufiq, 2016). Bloodworms (*Chironomus sp*. larvae) are another excellent source of natural feed with a protein content of 55.62%. Bloodworms have proven to be effective in juvenile feed, with studies showing growth improvements when used at specific feed rates (Sulistiyarto, 2016; Ndobe, 2017). This study aims to determine

the differences in the growth of Nirwana strain tilapia when fed with three different natural feeds: silkworms (*Tubifex*), bloodworms, and maggots.

Materials and methods

The research was conducted at the Laboratory of the Faculty of Fisheries and Marine Sciences, Jenderal Soedirman University.

Experimental Design

Nirwana strain tilapia juveniles were obtained from the Sidabowa Fish Seed Center in Purwokerto. The average weights of the fish used in each treatment were as follows: 9.06 ± 0.90 g for the silkworm (*Tubifex* sp.) treatment, 8.01 ± 1.06 g for the bloodworm (*Chironomus sp*.) treatment, 7.98 ± 1.63 g for the maggot treatment, and 7.89 ± 1.42 g for the control group (commercial pellets). The experimental design followed a completely randomized design (CRD) with three treatments, one control, and three replicates each. P0: Control, P1: *Tubifex*, P2: Bloodworm, P3: Maggot. *Tubifex* and *Chironomus sp*. larvae were provided directly to the fish, while the maggots were chopped before feeding. Fish were fed three times a day at 08:00, 14:00, and 18:00 at a feeding rate of 3% of the fish's body weight. The rearing method was modified from Salman (2008). Fish were reared in 30 x 40 x 30 cm aquariums filled with 10 liters of water, with a stocking density of 10 fish per aquarium. Weight and length measurements were taken every 10 days, while water quality parameters, such as dissolved oxygen (DO), pH, and temperature, were recorded daily."

Tilapia Growth Parameters

The work procedure was conducted systematically, starting with data collection to observe the growth of Nirwana tilapia. Growth was measured through parameters such as absolute length gain, absolute biomass gain, specific growth rate (SGR), and survival rate (SR). The following formulas were used to calculate growth:

Absolute length gain (Effendi, 1979):

$$P = Pt - Po$$

Where:

P = absolute length growth

Pt = The final length of the fish on day t

Po = Initial length of fish

Absolute Biomass (Effendi, 1979; Suprianto et al., 2019):

$$W = Wt - Wo$$

Where:

W = absolute weight/biomass growth

Wt = Final weight / fish biomass on day t

Wo = Initial weight/initial biomass of fish (g)

Specific growth rate (Abdel-Tawwab et al., 2010) :

$$SGR = [(\ln 〖Wt - \ln Wo\ ) / t] \times 100\%$$

Where:

SGR = Specific growth rate (% days)

Wt = Final average weight of fish on day t (g/head)

Wo = Average initial weight of fish (g/head)

t = Day

Survival rate data obtained using the following formula (Effendie, 2000) :

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

Where:

SR = Survival rate (%)

Nt = Number of fish at the end of the study (tails);

No = Number of fish at the beginning of the study (tails).

Data Analysis

Growth data were analyzed using ANOVA to determine any significant differences between treatments. If significant differences were found, Tukey's post-hoc test was performed to further analyze the data. Data processing was carried out using SPSS 25 software.

Results

Absolute Biomass Gain

The weight gain of the fish during each period is shown in Figure 1. The results indicate that *Tubifex* feed (P1) significantly increased the weight gain of the fish compared to other treatments. The highest absolute biomass was observed in the *Tubifex* group, with a value of 5.23 ± 0.89 g, followed by the Chironomus larvae (P2) at 4.22 ± 1.01 g, the maggot group (P3) at 3.93 ± 0.45 g, and the control group (P0, commercial pellets) at 3.24 ± 0.56 g (Table 1). Statistical analysis using ANOVA indicated significant differences among the treatments ($p < 0.05$). Tukey's post-hoc test revealed that the *Tubifex* treatment was significantly different from Chironomus larvae, maggot, and control treatments.

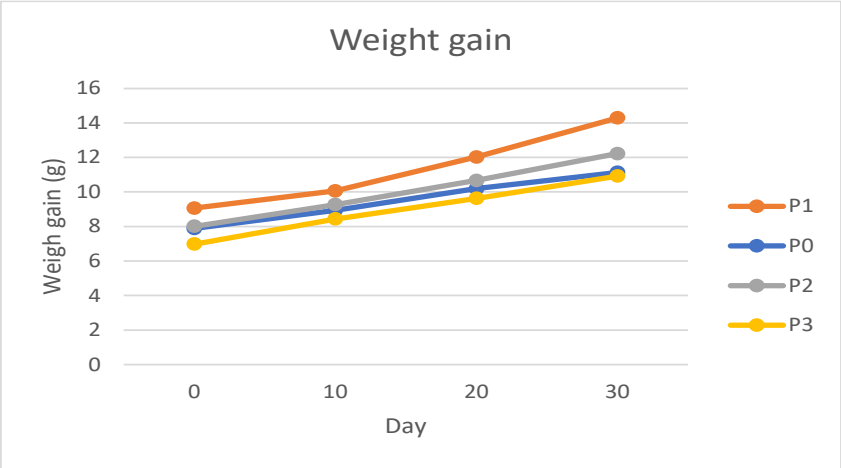

Figure 1. Tilapia nirwana strain weight gain in each time period

Table 1. Tilapia nirwana strain growth results with different natural feed

Experimental diets	W (g)	P (cm)	SGR	SR (%)
P0	$3,24 \pm 0,56^{a}$	$2,9 \pm 0,34^{a}$	$1,1 \pm 0,25^{a}$	100
P1	$5,23 \pm 0,89^{b}$	$4,2 \pm 0,78^{b}$	$1,53 \pm 0,33^{b}$	90
P2	$4,22 \pm 1,01^{a}$	$3,17 \pm 0,42^{a}$	$1,41 \pm 0,29^{b}$	100
P3	$3,93 \pm 0,45^{a}$	$3,1 \pm 0,45^{a}$	$1,33 \pm 0,23^{a}$	70
P-value <0.05	P < 0.0001	P< 0.0001	P< 0.034	-

However, there was no significant difference between the maggot and control treatments.

Absolute Length Gain

Fish growth was also assessed by measuring the increase in length. The results showed that the length of Nirwana tilapia increased significantly across all treatments during the experimental period. The highest absolute length gain was observed in the *Tubifex* group at 4.2 ± 7.8 cm, followed by Chironomus larvae, the control group (commercial pellets), and the lowest length gain was observed in the maggot group (Table 1). ANOVA analysis indicated significant differences in length gain between the treatments ($p < 0.05$). According to Tukey's post-hoc test, the *Tubifex* treatment was significantly different from Chironomus larvae, maggot, and control treatments. However, no significant differences were found between the maggot, Chironomus larvae, and control treatments.

Specific Growth Rate (SGR)

The Specific Growth Rate (SGR) results are shown in Figure 4. The SGR was highest in the *Tubifex* treatment, with an SGR value of 1.52 ± 0.33%/day, while the lowest SGR was observed in the control group at 1.1 ± 0.25%/day. ANOVA statistical analysis revealed significant differences in SGR among the treatments ($p < 0.05$). Tukey's post-hoc test indicated that the SGR for the *Tubifex* treatment was significantly different from the control, Chironomus larvae, and maggot treatments, while no significant differences were found between the control, maggot, and Chironomus larvae treatments.

Survival rate (SR)

The survival rate (SR) represents the percentage of fish that survived during the study period. The SR for the *Tubifex* group was 100%, while the lowest survival rate of 70% was observed in the maggot group (Table 1). The lower survival rate in the maggot group was likely due to the larger size of the chopped maggots, which may

Table 2. Water quality during tilapia maintenance period

Treatment	Range		
	Temperature (°C)	DO (mg/l)	pH
Control	25,2-28,5	4,3-7,1	7-8
P1	27,3-28,4	4,1-7,6	7-8
P2	25,2-27,7	4,6-7,3	7-8
P3	25,3-28,3	4,1-7,2	7-8

have made it difficult for some fish to eat, especially at the beginning of the experiment. High survival rates are usually achieved when the nutritional content of the feed matches the fish's needs. Feeds with low protein content have been linked to higher mortality rates (Martinez et al., 2016).

Water Quality

Water quality parameters were monitored regularly throughout the study. Temperature, DO, and pH were measured daily and remained within optimal ranges for the rearing of Nirwana tilapia (Table 2). The temperature ranged from 25.2°C to 28.5°C, DO levels ranged from 4.1 to 7.6 mg/L, and pH remained stable between 7 and 8. These parameters did not fluctuate significantly during the experimental period and were suitable for tilapia growth. According to Monalisa (2010), the optimal temperature for tilapia growth is 25-30°C, while a DO level above 5 mg/L is considered optimal (Kordi et al., 2007). The optimal pH for tilapia rearing is between 6 and 8.5 (Siegers, 2019), and this study's pH range of 7-8 falls within that optimal range.

Discussion

During the 30-day experimental period, fish fed with *Tubifex* showed the highest growth in terms of both absolute biomass, confirming that *Tubifex* provides the necessary nutrients for optimal growth in Nirwana tilapia. The findings are consistent with previous studies, such as Santos (2019), which reported that natural feeds like *Tubifex* significantly enhance fish growth due to their high protein content and easy digestibility. The absolute biomass gain of 5.23 ± 0.89 g (table 1) in this study aligns with Syahputra (2019), who observed a notable biomass increase in Carassius auratus larvae fed with *Tubifex* over 30 days. Similarly, Pratama (2021) found that *Tubifex* was the most effective natural feed for zebrafish larvae compared to other natural feeds like Moina and Chironomid larvae. The results study of Firli et al., (2021) show

that commercial feeding with a protein content of 40% and *Tubifex* produces the highest growth performance. *Tubifex* is considered the best natural feed because its nutritional content matches the needs of fish and shrimp (Herawati, 2017). *Tubifex* contains protein (50-55%), crude fiber (2-5%), and moisture (8-10%). *Tubifex*'s nutritional content is higher than Artemia and Daphnia's (Oplinger et al., 2011). *Tubifex* contains essential amino acids necessary for fish growth, such as lysine, methionine, threonine, leucine, isoleucine, valine, histidine, and tryptophan (Herawati et al., 2016). The balance of amino acids is crucial for fish growth (Hidalgo et al., 2002). However, several studies demonstrate that lysine and methionine play a significant role in protein synthesis and tissue repair, contributing to improved growth and feed efficiency in fish (Li et al., 2009; Wilson, 2002; Francis, 2001; Kaushik, 2010).

Regarding the absolute length gain of tilapia larvae, there was a statistical difference between *Tubifex* feed and other treatments, with a value of 4.2 ± 0.78 (P1). This value is the highest compared to the control or Chironomid and maggot feed. A combination of 75% *Tubifex* feed was able to increase the absolute length of Sangkuriang catfish (Clarias gariepinus) larvae by 42.3% compared to commercial pellet feed (Mullah, 2019). Similarly, the highest absolute length increase in Pangasius sp. larvae was obtained from *Tubifex* feed (Idawati, 2018). Most freshwater fish larvae prefer *Tubifex* due to its distinctive aroma, color, and smaller size compared to other natural feeds.

The specific growth rates (SGR) of tilapia were found to be the lowest at 1.1 ± 0.25 (P0) and the highest at 1.53 ± 0.33 (P1), with a significant difference ($p < 0.05$) between the treatments. The precise amount of feed needed by fish at various growth stages can be calculated by knowing the specific growth rate (SGR) (Rahman et al., 2022). The percentage increase in size and weight at specific growth stages in relation to time (SGR) is crucial for determining the amount of feed required for that stage to ensure successful aquaculture operations (Islam, 2023). With a higher SGR, *Tubifex* shows that fish can convert feed into body mass more efficiently compared to maggot feed. This means that fish can obtain more energy and building materials from *Tubifex* for growth (Ahmad et al, 2004; Wang et al, 2013; Azaza et al, 2008).

Parameters such as absolute biomass, absolute length, and Specific Growth Rate (SGR) indicate that *Tubifex* treatment

Table 3. Nutritional content of Maggot, *Tubifex* sp, and Chironomous sp. larvae.

No	Natural Feed	Unit	Test Results		
			Carbohydrate	**Protein**	**Fat**
1	Maggot	%	11,89 - 24,75	37,97- 44,58	1,56- 6,85
2	*Chironomous* sp. larvae	%	15.40	56.6	2.8
3	*Tubifex sp*	%	20.3	57	13,3

Sources: Indariyanti (2018), Anggraeni (2013), Weisman et al (2015)

provides better growth compared to maggot and Chironomid larvae. The protein content of *Tubifex* is 57%, Chironomid larvae 55.62%, and maggot 30-45%. The nutritional needs of tilapia larvae are 50% protein and 8% fat, while adult fish require 25-30% protein and 7% fat (Mulqan, 2017). This indicates that *Tubifex* can meet the protein needs of tilapia.

Although Chironomid larvae also have a protein content of up to 50%, their heads have hard sucking-type mouths (Indra, 2013). According to Cho et al. (1985), crude fiber affects protein digestibility, as a larger portion of excreta results in reduced digestible protein input, which affects protein digestibility. *Tubifex*, lacking a hard exoskeleton and containing less crude fiber, is more easily digestible by fish (Suprapto et al., 2012). Additionally, *Tubifex* contains several digestive enzymes that act as exogenous enzymes, helping to improve fish digestion (Prasetya et al., 2020). *Tubifex* contains several important enzymes involved in antioxidant defense, including catalase and superoxide dismutase (SOD) (Saha et al., 2024). *Tubifex* has been shown to provide better growth in fish. Substituting 15% *Tubifex* feed can increase the specific growth rate by 2.15% and length by 2.28 cm, and reduce the FCR value in catfish larvae (Islama, 2019). The growth of Nirwana tilapia with maggot feed was low and did not significantly differ from the control. In terms of feed application, the coarsely cut maggot made it difficult for fish to consume. Additionally, the chitinous shell of maggots makes digestion more challenging for fish, causing them to expend more energy on digestion, leading to less optimal growth (Murni, 2013).

Tubifex has a high protein content of up to 57% (Table 2). The protein in *Tubifex* is of high quality, containing all essential amino acids required by fish. This is important to ensure optimal growth and overall health (Herawati et al., 2020). Besides the protein content meeting tilapia needs, other nutrients like carbohydrates and fats should also be balanced for optimal

growth. Pieper and Pfeffer (1980) state that carbohydrates are an effective energy source, as are fats. Lovell (1989) suggests that the energy provided by feed should be optimal because growth reduction can occur if energy is either too high or too low. Carbohydrates also play a role in saving protein use as the primary energy source for the fish body. If protein is used excessively for energy needs, it can result in reduced fish growth. Tilapia is an omnivorous fish, with carbohydrate requirements of 20-40% (Amarwati, 2015). From Table 2, it can be seen that *Tubifex* has a fat content of 13%. Fat content in feed up to 11% and 13% can enhance feed utilization efficiency and protein efficiency (Nyina-Wamwiza et al., 2005). Maximum fat use in feed can improve growth and has a protein-saving effect, reducing production costs (Midelan Redding, 2000). Fat is an easily digestible energy source, enhances nutrient absorption, acts as a carrier for fat-soluble vitamins, and improves membrane resilience.

Water quality in this study is a crucial supporting parameter for the survival of Nirwana strain tilapia. Water, as the fish's habitat, must meet specific requirements. Maintaining optimal water quality is necessary to create a suitable environment for Nirwana tilapia. Supporting parameters in this study included water quality parameters such as temperature, DO, and pH. In this study, the temperature ranged from 25.5 – 28.3°C (Table 3). According to Monalisa (2010), the optimal temperature for tilapia is 25-30°C, while Dadiono et al. (2017) state that 25 – 27°C is still considered a good temperature for freshwater fish. Optimal temperature will ensure that digestive enzymes function effectively (Kelabora, 2010). Temperatures above the optimal range can cause protein denaturation, reduce enzyme performance, and damage membrane integrity, accelerating fish death. Conversely, temperatures below the optimal range can reduce fish appetite and nutrient intake. Both excessively high and low temperatures can decrease fish growth.

Another crucial water quality parameter affecting fish growth is Dissolved Oxygen (DO). The oxygen content in water is closely related to temperature; if the temperature exceeds the optimal range, DO content decreases. In this study, DO ranged from 4.1-7.6 mg/l. According to Kordi et al. (2007), the optimal DO level for fish is 5 mg/l. Fish can still survive with reduced appetite even if DO is below 4 mg/l. Oxygen is not only used for respiration but also as fuel for metabolism. Fish given more feed

will require more oxygen for digestion. pH during tilapia rearing ranged from 7-8, which is an optimal pH value. The optimal pH for tilapia cultivation is 6-8.5 (Siegers, 2019). Optimal growth of carp occurs at pH = 8.5, and the lowest growth occurs at pH = 5.5. Extreme changes in pH can disrupt respiration (Alabaster and Loyn, 1982). Growth can be hindered, and fish may become susceptible to diseases if the water becomes toxic due to high pH (Khordi, 2010). Ammonia concentrations can increase if pH exceeds the optimal range (Irawan, 2019). pH levels that can cause fish death are below 4 and above 11 (Tambunan, 2019).

Conclusion

In conclusion, *Tubifex* proved to be the most effective natural feed for enhancing the growth of Nirwana tilapia juveniles in terms of absolute biomass, length, and SGR. The superior nutritional content and digestibility of *Tubifex* contributed to these results. Although Chironomus larvae also provided good growth, their harder exoskeleton may limit their effectiveness compared to *Tubifex*. Maggots, while a cost-effective alternative, require further refinement in preparation to maximize their utility as a natural feed. Maintaining optimal water quality is essential for the success of aquaculture, as it supports the health and growth of the fish. Future research could explore the long-term effects of using these natural feeds, particularly in larger-scale tilapia farming operations, and the potential for combining different natural feeds to optimize growth and reduce production costs.

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