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The growth of bloodworm, Chironomidae larvae (Diptera) fed with fish waste and chicken manure

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Abstract
The aim of this study was to evaluate the growth of bloodworms that were fed with Nile tilapia (*Oreochromis niloticus*) waste, Climbing Perch (*Anabas testudineus*) waste and chicken manure. The study used a completely randomized design with 3 treatments and 3 replications. Bloodworms were reared in a 40 X 30 X 13 cm plastic container filled with 8 l of water. Food items were provided into culture media at the rate of 1.5 $g.l^{-1}$. Bloodworm larvae aged 1 day were stocked at a density of 1000 individuals/container and harvested at day 11. The results show that the survival rate of bloodworms was 43.83-52.43%. Bloodworms fed with Nile Tilapia waste, Climbing perch waste, and chicken manure had length growth rates of 0.769 $mm.d^{-1}$, 0.781 $mm.d^{-1}$ and 0.837 $mm.d^{-1}$ respectively. The protein content of bloodworms harvested ranged from 38.63–50.12% and is still suitable for the nutritional needs of fish.

Keywords: Chironomidae, aquaculture waste, aquatic invertebrates culture, ornamental fish feed

Introduction

Chironomidae is classified as a winged insect of the order Diptera. The life cycle of Chironomidae includes 4 phases of metamorphosis. The egg, larval and pupal phases live in water while the adult phase lives as flying insects [1]. Chironomidae larvae are known as Bloodworms because their body is cylindrical like a worm and has a red color due to the hemoglobin content in its body [2]. The larval phase, known as the bloodworm takes 8-12 days, and after that it will turn into a pupa [3].

Bloodworm is a natural fish feed that is widely used as ornamental fish feed. Aquarists like to provide their ornamental fish with natural food, because it can produce ornamental fish with good performance, and tends not to cause a decrease in water quality due to the accumulation of organic matter. Bloodworms are superior for ornamental fish feed compared to other feeds because they meet the nutritional needs of freshwater fish [4], with a high protein content of 52.11% and 4.50% fat [5] thus supporting fish growth [6]. Bloodworms are palatable for many species of ornamental fish [7, 8], and contain carotene which stimulates fish pigmentation [9]. Bloodworms are used as ornamental fish feed, sold as live bloodworms, frozen bloodworms, freeze-dried bloodworms and bloodworm gel food [10]. Most bloodworms for fish feed still come from wild capture. Therefore bloodworm culture technique needs to be developed so that it can meet the high demand for ornamental fish feed.

Bloodworms naturally feed on organic matter or detritus at the bottom of the waters. According to Naser and Roy [11] about 50-55% of the material eaten by bloodworms is detritus. Several studies have reported the use of various types of organic matter for feed in bloodworm cultures. Organic waste is a potential feed for bloodworms because it is a material that is no longer useful but still has nutritional content. Organic waste that has been used for bloodworm cultivation includes chicken manure, cow dung, duck waste, and vegetable waste [12-14]. Chicken manure has been used for the mass production of bloodworms [15]. Fish waste is an organic material that is always abundant in fish farming locations which can be a source of bloodworm feed. According to research by Shi *et al.* [16], fish waste from Catfish contains 39.55% organic carbon. This study evaluated the growth of bloodworms that were fed with Nile tilapia (*Oreochromis niloticus*) waste, Climbing Perch (*Anabas testudineus*) waste and chicken manur.

Materials and Methods

This bloodworm culture study was conducted at Aquaculture Laboratory of Palangka Raya Christian University in an outdoor place with a polycarbonate canopy and received indirect sunlight. Bloodworm larvae were obtained by incubating bloodworm eggs in plastic containers filled with clean water. Bloodworm eggs were collected from bloodworm culture cages in the Laboratory.

The study used a completely randomized design with 3 treatments and 3 replications. The treatment was feeding bloodworms with different types of feed: A. Nile Tilapia waste, B. Climbing Perch waste, and C. Chicken manure. Chicken manure was obtained from household poultry and fish waste from fish culture tanks. Fish waste was siphoned, precipitated, and filtered using a cloth. All food items were dried under sunlight for 3 days, than ground and sieved. Food items were provided into culture media at the rate of 1.5 $g.l^{-1}$. Bloodworms were reared in a 40 X 30 X 13 cm plastic container filled with 8 l of water and covered with a nylon net (Figure 1). Bloodworm larvae aged 1 day with an initial body length of 1.2 mm were stocked at a density of 1000 individuals/container. The bloodworms were harvested at day 11 and the number of living bloodworms was calculated to determine the survival rate. The body length of the bloodworm samples was measured to calculate length growth rate. Body length was measured from the anterior end to the anus using a micrometre of a digital microscope with 30X magnification. Daily growth rate (GR) in body length was calculated as GR ($mm.\ d^{-1}$) = (Final length - initial length)/ cultivation day. The effect of food items on bloodworm growth rate was analyzed using one-way ANOVA and means were separated by LSD (Least Significant Difference) test.

The proximate nutritional content of the food items used and harvested bloodworms was analyzed using the AOAC method [17] which included crude protein, crude fat, and crude carbohydrates. Water quality parameters including dissolved oxygen levels, water pH, and water temperature were observed at the beginning and end of the study.

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Fig 1: Plastic container for bloodworm culture

Results

The organic materials used for bloodworm culture media in this study were fish waste obtained from concrete culture tanks of Nile Tilapia and Climbing Perch and chicken manure. All organic wastes were used in dry form and finely ground. According to proximate analysis, the protein content of fish waste is higher than chicken manure. Meanwhile, the nutritional content of Nile Tilapia waste and Climbing Perch waste were very similar (Table 1).

When the food items were spread into bloodworm culture media according to the experimental design, it immediately caused the water to become cloudy. The organic matter in the food items underwent a decaying process during the culture period, which affected water quality conditions. Table 2 shows the condition of water quality at the beginning and end of the study.

Table 1: Mean± SD of the nutrition content of food items used for bloodworm culture

Food items	Crude Protein (%)	Crude Fat (%)	Crude Carbohydrate (%)
Nile tilapia waste	30.44±0.64	0.47±0.03	35.51±1.31
Climbing perch waste	29.99±0.63	0.54±0.03	35.61±0.75
Chicken manure	11.95±0.10	0.09±0.01	27.88±0.25

Table 2: Mean±SD of water quality parameters of bloodworm culture media

Parameters	1st –day	11th -day
Dissolved Oxygen ($mg.l^{-1}$)	3.66±0.55	3.51±0.44
pH	7.07±0.62	7.01±0.64
Temperature (°C)	29.67±0.07	28.77±1.13

1000 bloodworm larvae were stocked for initial population of each container. During 11 days of rearing, the population number decreased due to some of the larvae being dead. The survival rate of bloodworms fed with Nile Tilapia waste, Climbing Perch waste and chicken manure was 49.53%, 52.43% and 43.83% respectively. Bloodworms were harvested at day 11, and then their body length was measured. The average body length of bloodworms fed with Nile Tilapia waste, Climbing Perch waste, and chicken manure were: 9.664±1.574 mm, 9.786±1.464 mm, and 10.411±1.669 mm respectively. Growth rate of the bloodworms were presented in Figure 2. Bloodworms fed with Nile Tilapia waste, Climbing perch waste, and Chicken manure had length growth rates of 0.769 $mm.d^{-1}$, 0.781 $mm.d^{-1}$ and 0.837 $mm.d^{-1}$ respectively.

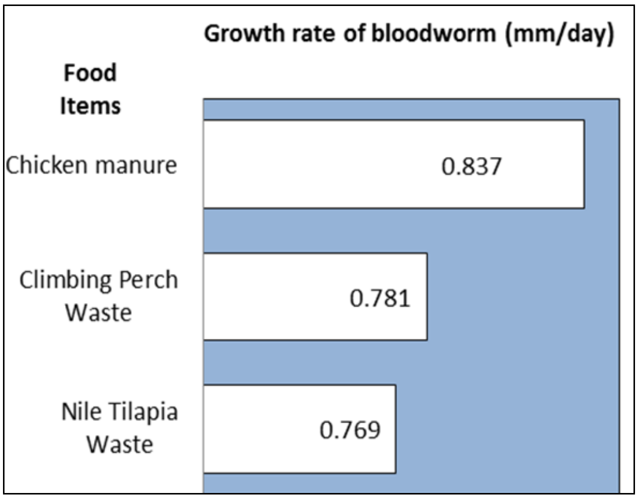

Fig 2: Growth rate in body length of the bloodworm with different foods

Results of variance analysis (ANOVA) showed that the growth rate of bloodworms was significantly influenced by food items (F_{value} = 9.53). LSD test indicated that the highest growth rate was obtained by feeding chicken manure.

Meanwhile, the growth rate of bloodworms fed with Nile Tilapia waste and Climbing Perch waste were not different. Harvested bloodworms were analyzed proximately to determine their nutritional content, as shown in Table 3. Bloodworms fed with Nile tilapia waste and Climbing Perch waste had almost similar nutrients, meanwhile, Bloodworms fed with chicken manure have a higher protein and fat content.

Table 3: Mean± SD of nutrition content of bloodworm by different foods

Food Items	Crude Protein (%)	Crude Fat (%)	Crude Carbohydrate (%)
Nile Tilapia waste	38.63±0.23	1.79±0.04	25.37±0.04
Climbing Perch waste	39.86±0.46	1.62±0.08	24.24±0.56
Chicken manure	50.12±0.36	4.27±0.11	23.99±0.19

Discussions

In aquaculture industry, fish waste is useless and pollutes the environment. Based on the proximate analysis conducted in this study, fish waste from fish tanks still had sufficient nutrition (Table 1). These results indicated that the nutrients from commercial fish feed were not used efficiently by fish so fish waste still contained nutrients. Bloodworms are detritus-eating invertebrates, so they can utilize the remaining nutrients in fish waste for their survival and growth. The survival rate (SR) of bloodworms fed with Nile Tilapia waste, Climbing Perch waste and chicken manure was 49.53%, 52.43% and 43.83% respectively. The SR of bloodworms during this study were relatively low compared to other studies such as Widanarni *et al.* [18] Obtained SR 50.71-58.93% by providing solid sago waste substrate, and Podder *et al.* [14] obtained SR 87.66-95.33% using chicken manure substrate. In our study, the using fish waste obtained higher SR than chicken manure. The survival rate of bloodworms in culture is probably influenced by the type of feed substrate and water quality conditions. In a natural water body, the abundance of bloodworms depends on the availability of organic material in the basic substrate as a food source [19], and water quality conditions [20, 21, 22]. In aquaculture industry, fish waste is useless and pollutes the environment. Based on the proximate analysis conducted in this study, fish waste from fish tanks still provided sufficient nutrition (Table 1). These results indicated that the nutrients from commercial fish feed were not used efficiently by fish so fish waste still contained nutrients. Bloodworms are detritus-eating invertebrates, so they can utilize the remaining nutrients in fish waste for their survival and growth. The survival rate (SR) of bloodworms fed with Nile Tilapia waste, Climbing Perch waste and chicken manure were 49.53%, 52.43% and 43.83% respectively. The SR of bloodworms during this study were relatively low compared to other studies such as Widanarni *et al*. [18] Obtained SR 50.71-58.93% by providing solid sago waste substrate, and Podder *et al*. [14] obtained SR 87.66-95.33% using chicken manure substrate. In our study, the using fish waste obtained higher SR than chicken manure. The survival rate of bloodworms in culture is probably influenced by the type of feed substrate and water quality conditions. In a natural water body, the abundance of bloodworms depends on the availability of organic material in the basic substrate as a food source [19], and water quality conditions [20, 21, 22]. Fish waste and chicken manure are used by bloodworms as food sources and also as material to make their tubes. These tubes are used to protect bloodworms from unfavourable environmental conditions [14].

The process of decaying fish waste and chicken manure during the culture contributes to water quality degradation. Water quality conditions that can still be tolerated by bloodworms are as follows: water temperature 25-30 ^{O}C [23], dissolved oxygen of at least 3 mg l^{-1} [24], and pH 6-9 [25]. Based on the results of measuring the water quality of the bloodworm culture media at the beginning and end of the study (Table 2), we concluded that the conditions of temperature, pH and dissolved oxygen during the study still supported bloodworm life.

The results of body length measurements of bloodworms reared for 11 days ranged from 9.664-10.411 mm. In other studies, bloodworm body length varies, such as: 6.28-9.29 mm [26], 7.1-7.9 mm [18], and 9.6-10.5 mm [12]. This variation in body length is caused by the provision of different types of feed. Within 11 days, the growth rate of bloodworm ranged from 0.769-0.837 mm.d^{-1}. Feeding with fish waste resulted in a lower growth rate compared to chicken manure. Chicken manure may provide a more suitable substrate composition for bloodworms. Decaying in fish waste may be greater than in chicken manure because it contains higher protein, fat and carbohydrates. The growth and development times of aquatic invertebrates are influenced by temperature, food, or both [34]. The availability of suitable feed will support the growth of bloodworms. Temperature also has an important role in determining bloodworm growth [28].

The protein content of feed has an important role for fish farming because protein is the main component of feed that responds to fish growth. Bloodworm protein content from this study ranged from 38.63-50.12%. (Table 3). Bloodworms fed with chicken manure had a higher protein content than those fed with fish waste. The range of protein levels in bloodworms in this study still meets the nutritional needs of fish in general. A protein content of 30 – 40% in fish feed is sufficient for optimal fish growth [29]. Several studies have shown that the protein content of bloodworms varies, such as: 55.62% [30], 55.4% [31], 52.11 % [5], 41.8% [32], and 26.06 % [33]. The protein content in bloodworms can be affected by the different types of feed used in the culture [9].

Conclusion

Fish waste can be used as a source of bloodworm feed. This utilization contributes to converting fish manure waste into high-nutrition bloodworm biomass and valuable fish feed. Bloodworms can be harvested in a short time, only 11 days of cultivation. Bloodworms fed with Nile Tilapia waste and Climbing Perch waste had length growth rates of 0.769 mm.d^{-1}, and 0.781 mm.d^{-1} respectively. Feeding with chicken manure resulted in a higher Bloodworm growth rate of 0.837 mm.d-1. The protein content of bloodworms from the results of this study ranged from 38.63-50.12% and was still suitable for the nutritional needs of fish. Feeding with chicken manure produced bloodworms with higher protein content than feeding with fish waste.

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