The effect of flour-based feed black soldier fly larvae on crayfish (*Cherax quadricarinatus* von Martens) growth

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Abstract. Feeding in accordance with the level of nutritional needs can support the optimum growth of crayfish. Black Soldier Fly (BSF) larvae has potential as feed source because it contains high protein, relatively short harvest period, available in abundance. This study aims to determine the effect of feed pellets made from BSF larvae flour on the growth of crayfish. This research was carried out from October 2022 to January 2023 at the Zoology Laboratory of the Biology Education Department, University of Jember. This study used a laboratory experimental method with a completely randomized design (CRD). The research used 3 treatments and 3 replications, namely control (P0) using fish flour-based feeding, treatment 1 (P1) using BSF flour-based feed, and treatment 2 (P2) using fish flour and BSF flour-based feed. Parameters observed include carapace length, wet biomass, dry biomass, Feed Utilization Efficiency (FUE), and Feed Conversion Ratio (FCR) that measured once a week. The results showed that the three treatments had no effect significantly. Based on the result, pellet feed designed using BSF larvae flour and fish flour can be recommended as an alternative feed for replacement pellet feed that formulated using fish flour.

1 Introduction

Crayfish (*Cherax quadricarinatus* von Martens) is one type of Crustacea that has potential as a cultured animal because it has several advantages, namely its simple life development without going through complicated larval stadia [1,2]. This crayfish also has been widely developed on an aquarium and pond scale as an ornamental and consumption commodity [3]. These lobsters are reported not easily stressed or susceptible to disease, if their feed needs, water quality, and oxygen needs are in adequate. In addition, *Cherax quadricarinatus* has a very high nutritional content, low fat content and a relatively tasty and tender meat structure [4], so crayfish are widely traded for consumption and aquarium decoration [5].

There are many types of feed used for crayfish cultivation. *Cherax quadricarinatus* really needs artificial feed with sufficient protein for growth. However, the many types of crayfish

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feed make it difficult for farmers to determine the type of feed with good quality and most of them still do not pay attention to good crayfish feed formulations [6]. Pellet feed is one type of feed that is in great demand by crayfish farmers, because pellets include commercial feed that has been formulated with certain formulations specifically for the nutritional needs of crayfish [7]. Feed pellets commonly used by crayfish farmers are fishmeal-based pellets as a source of protein. However, the reduced availability of fishmeal and the increasing price of fishmeal have prompted to get alternative protein source substitutes [8].

BSF larvae has been studied for its characteristics and nutritional content. BSF larvae have a high protein content compared to other insect species developed as feed. [9]. The protein content of BSF larvae is 40-50% with fat content ranging from 29-32% [10 ,11]. BSF larvae as a source protein have some advantage such as relatively short harvest period, which is around 10-24 days, so BSF flour has the potential as crayfish feed [9].

2 Materials and Methods

2.1 Place and Time of Research

This research was conducted in the Zoology Laboratory of Biology Education Department, University of Jember. The research was conducted from October to December 2022.

2.2 Research Methods

The method used in this research was laboratory experimental using a completely randomized design (CRD), with 3 different treatments and using 3 replications for each treatment to measure its effect the treatment on crayfish growth. The treatments used in this research were Control Treatment (P0) with fish flour-based pellet feeding; Treatment 1 (P1) with BSF flour-based pellet feeding; Treatment 2 (P2) with BSF flour-based pellet feeding combination with fish flour.

The crayfish rearing media uses plastic containers measuring 47×33×15 cm in length, width, and height respectively. The crayfish used in this study were crayfish aged about 2-3 months with biomass of 2.1 (±0.5) g and carapace length of 20 (±1.7) mm obtained from Freshwater Crayfish Farmers, Pakusari, Jember Regency. Before being given the treatment of test animals, acclimatization is carried out first for 7 days, the aim of the acclimatization is to adapt the crayfish on new water conditions. Total number of crayfish used for every treatment and replicate was 90 individuals with 10 individual/container. To get dry biomass data during the research, it used aliquot design which similar research design with main research. It used 108 crayfish with 12 crayfish /container as an aliquot. The crayfish growth of this research measured with parameters, such as: wet and dry biomass, carapace length, Feed Conversion Ratio (FCR), and Feed Utilization Efficiency (FUE). The data was measured every week. For dry biomass data was measured from the aliquot to get regression equation reflected the relationship between dry biomass and wet biomass of the crayfish. The equation then used to calculate dry biomass the main research based on wet biomass that was measured.

2.3 Feed Composition

This research used three different feeds for control and treatments with source composition for every feed that was showed Table 1. The control (P0) with fish flour-based pellet feeding and formulation using all sources listed in table 1 was adopted from [6], and treatment 1 (P1) with BSF flour-based pellet feeding, and treatment 2 (P2) with BSF flour and fish-flour based

pellet feeding were designed to replace the portion of fish flour in [6] formulation. During the research the crayfish was supplied the feed as 10% of the crayfish wet biomass. Besides the main data, this research measured same parameters such as: feed residue (gram) and feces weigh (gram), water temperature, water acidity (pH), and dissolved oxygen (DO) that was recorded every day.

Table 1. Proportion of feed sources for Control (P0), Treatment 1 (P1), and Treatment 2 (P2).

Feed sources	The proportion of each treatment		
	P0 (%) *	P1 (%)	P2 (%)
BSF larva flour	0	29,28	14,64
Fish flour	29,28	0	14,64
Soybean meal flour	27,10	27,10	27,10
Corn flour	16,10	16,10	16,10
Rice bran	14,90	14,90	14,90
Flour	9,43	9,43	9,43
Vit Min Mix	2,10	2,10	2,10
CMC	1,10	1,10	1,10

* Source: Adaptation of [6]

2.4 Research Parameters

Measurement of wet and dry biomass of crayfish of the study using the formula:

$$\text{Biomass growth} = Wt - W0. \quad (1)$$

Description:
Wt = Average wet/dry biomass at week t
W0 = Average wet/dry biomass at week 0 [12].

Carapace length growth measurements can use the formula:

$$\text{Carapace length growth} = Lt - L0. \quad (2)$$

Description:
Lt = Average carapace length at week t
L0 = Average carapace length at week 0 [13].

Feed Conversion Ratio (FCR) is the ratio between the amount of feed consumed and the amount of crayfish weight produced. According to [6] feed utilization efficiency is the percentage between body weight gain and the amount of feed given during the research. The formula for calculating FCR [14] is as follows:

$$FCR = \frac{F}{(Wt + D) - Wo} \quad (3)$$

Description:
FCR= Feed Conversion Ratio
F = Average feed consumed during the study (g)
Wt = Average biomass of test crayfish at the end of the study (g)
Wo = Average biomass of test crayfish at the beginning of the study (g)
D = Biomass of dead test animals (g)

Feed utilization efficiency [15] is calculated based on the following formula:

$$FUE = \frac{(Wt - Wo) + D}{F} \times 100\% \quad (4)$$

Description:
FUE= Feed Utilization Efficiency (%)
Wt = Average biomass of test crayfish at the end of the study (g)
Wo = Average biomass of test crayfish at the beginning of the study (g)
F = Average feed consumed during the study (g)
D = Biomass of dead test crayfish (g)

2.5 Data Analysis

Data at the beginning of the study had been tested for normality and homogeneity, which showed that the data were normally distributed and homogeneous with significance ($p = 0.24$ and $p = 0.68$). At the final step, the observation data obtained was analyzed using the Analysis of Variance (Anova) test at the 95% confidence level. This test aims to determine the effect of all treatments on the growth of *Cherax quadricarinatus*, and then Duncan test was carried out to determine the difference in feed treatments that have the most significant effect. The ANOVA test and Duncan test were conducted using SPSS Statistics 26 software.

3 Results and Discussion

3.1 Result

Before feeding the pellets were used for the treatment, a proximate test was conducted to determine the nutrient content. The results of the proximate test can be seen in Table 2.

Table 2. Proximate Test Results of Feed Pellets of P0, P1, and P2*.

Kind of pellet feed	Water (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)
Fish flour (P0)	5.97	13.81	6.52	15.99	57.70
BSF larva flour (P1)	10.14	9.93	7.07	18.38	54.49
Combination of BSF larva flour and fish flour (P2)	10.78	9.79	6.89	20.10	52.45

Notification:
*Proximate test results were conducted at the Analytical Laboratory of Jember State Polytechnic in December 2022.

3.1.1 Wet and Dry Biomass Growth

The results of the effect of treatment on dry biomass growth of crayfish (*Cherax quadricarinatus*) can be seen in the Table 3. It shows that the highest dry biomass growth occurred on P2 (feed pellets made from BSF larvae flour and fish flour) was 0.10 (± 0.03) g/4 weeks, while on P0 (fish flour- based pellet feed) and P1 (fish flour- based pellet feed) were 0.08 (± 0.05) g/ 4 weeks and 0.09 (± 0.01) g/ 4 weeks respectively. Similarly, wet biomass growth of crayfish shows that the best growth occurred on P2 (feed pellets made from BSF larvae flour and fish flour) was 0.42 (± 0.10) g/4 weeks, while on P0 (fish flour-based pellet feed) and P1 (fish flour- based pellet feed) were 0.32 (± 0.11) g/ 4 weeks and 0.37 (± 0.47) g/ 4 weeks respectively. This is because the pelleted feed made from BSF larvae flour and fish flour based showed the highest protein content of 20.10% based on the proximate test results (Table 2). Meanwhile, pelleted feed made from BSF larval flour has a protein content of 18.38% and pelleted feed made from fish flour has the lowest protein content of 15.99%. The growth of *Cherax quadricarinatus* according to [16] is largely

determined by the protein content in the feed. Feed with high protein content in sufficient doses and support the crayfish growth optimally. According to [17] that protein and carbohydrates are the nutrients most needed for the growth and activities of *Cherax quadricarinatus*. The protein requirement in *Cherax quadricarinatus* is 21.6%, carbohydrates are 29.4%, and fat is 7% [18]. The utilization of BSF larvae in aquaculture has been widely applied. However, this study utilizes BSF larval flour as the basic ingredient of *Cherax quadricarinatus* feed in the form of pellets with a mixture of other ingredients as complementary nutrients, so it has great potential with the advantages of BSF larvae and is supported by the results of this study.

However, based on Anova test showed that the different feed treatments had no significant effect with significance (p=0.66) on wet biomass growth and on dry biomass growth (p=0.73) of *Cherax quadricarinatus*. It proves that the treatments (P1 and P2) are good pellet feeds that can be used for replacement the pellet feed fish meal based. The finding of the research is very important because it has a potential solve the crayfish famers as discussed previously regarding to fish flour availability and tend to be expensive.

Table 3. Mean of carapace length growth of *Cherax quadricarinatus* on P0, P1, and P2.

Treatment	Dry biomass growth (g/4 weeks)	Wet biomass growth (g/ 4 weeks)	Carapace length growth (mm/4 weeks) *
P0	0.08 (± 0.05)[a]	0.32 (± 0.11)[a]	1.25 (± 0.58)[a]
P1	0.09 (± 0.01)[a]	0.37 (± 0.47)[a]	1.56(± 0.14)[a]
P2	0.10 (± 0.03)[a]	0.42 (± 0.10)[a]	1.85 (± 0.31)[a]

Notification:
* : Based on the Duncan test, values with the same superscript in the table indicate a non-significant effect (p>0,05);
P0 : fish flour- based pellet feed
P1 : fish flour- based pellet feed
P2 : feed pellets made from BSF larvae flour with fish flour

3.1.2 Carapace Length Growth

Carapace length growth of crayfish shows in the Table 3. It shows that the highest growth occurred on P2 (feed pellets made from BSF larvae flour and fish flour) was 1.85 (± 0.31) mm/4 weeks, while on P0 (fish flour- based pellet feed) and P1 (fish flour- based pellet feed) were 1.25 (± 0.58) mm/ 4 weeks and 1.56 (± 0.14) mm/ 4 weeks respectively.

Based on Anova test revealed that treatments had no significant (p=0.74) on the carapace length growth of *Cherax quadricarinatus*. Feeding pellets made from BSF larvae flour and fish flour gave the highest growth with an average of 1.8482 mm/4 weeks in treatment 2 (P2). This means that treatment 2 showed the best growth results compared to the other treatments. This indicates that the protein content in the pellet feed is able to contribute positively to the growth of *Cherax quadricarinatus* seeds. According to [15] states that protein in feed is an absolute requirement to support growth and to recover damaged cells.

3.1.3 Feed Utilization Efficiency and Feed Conversion Ratio

Based on the FCR analysis (Figure 1) shows that the treatment of feeding pellets made from a combination of BSF larval flour and fish flour (P2) shows the best feed with FCR was 1.7167, while on P0 (fish flour- based pellet feed) and P1 (fish flour- based pellet feed) were 2.3033 and 2.1666 respectively. According to [19] a fairly good FCR value ranges from 0.8-1.6. The FCR in this study especially for P2 is almost close to this value, so it can be said

that *Cherax quadricarinatus* in P2 can utilize the feed given optimally. The small value of the FCR mainly due to the different absorption of nutrients in each treatment.

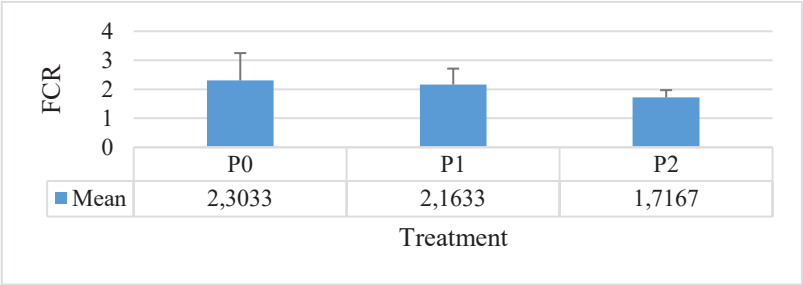

Fig. 1. Mean of FCR of *C. quadricarinatus* on P0, P1, and P2.

The effect of treatment on Feed Utilization Efficiency (FUE) shows Figure 2. The FCR of pellet feeding treatment made from a combination of BSF larval flour and fish flour (P2) is the best feed compared to other treatments, which is 59.0533%. The standard FUE for crayfish is 50%. The higher the feed utilization efficiency value reflects the better the feed quality [20, 21].

Based on the FCR and EPP values obtained, also reflects a good finding because it can recommend as a new feed formulation. The pellet formulated BSF larva flour based and mixing of fish flour and BSF larval flour based as raw material can be used as a good pellet formulation for *Cherax quadricarinatus* growth to replace the common pellet formulated using fish flour based regarding give similar effect on the cray fish growth but it is more efficiently based on the data of FUE and FCR.

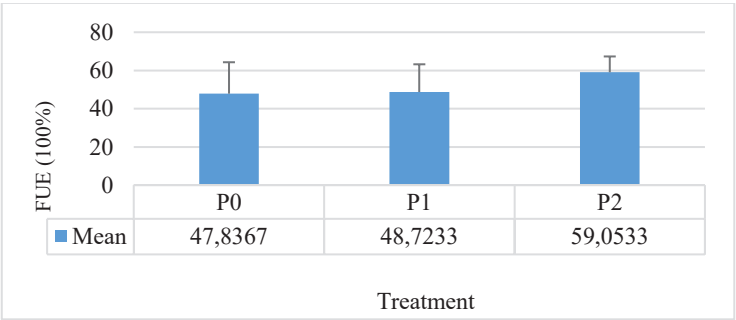

Fig. 2. Mean of FUE pellet feeding treatment P0, P1, and P2 on *C. quadricarinatus*.

3.1.4 Abiotic Factors

Water quality parameters during the study were measured including water temperature (oC), acidity (pH), dissolved oxygen (DO), and light intensity (lux). The results of water quality measurements during the study are presented in Table 4. Based on the data shows that the pH range during the research is 7.24 – 7.27, while the optimum pH for the crayfish is 7.0 – 9.0 [6]. It shows that the water quality based on pH parameters is in the range of optimum. It is similarly conditions for water temperature, light intensity, and DO. Water temperature during the research shows in the range of 24.89 – 25.1°C, while the water optimum temperature for the crayfish is 25-32°C [4, 22]. Light intensity range during the day in this research area is 174.56 – 176.89 lux, and the condition water media of crayfish there is available shelter made from PVC pipe. The crayfish as nocturnal aquatic animal preference in the shelter [22], and the range may no effect on the activity of the crayfish. The water temperature range closely

confirms the optimum temperature range. While the DO range of the research is 4.62 – 4.82 ppm and the optimum range is 4-6 ppm [4, 21]. It shows that the crayfish in optimum range of DO.

Table 4. Results of water quality parameters during the research.

Week	pH	Water temperature (°C)	Light intensity (Lux)	DO (ppm)
W0	7.24±0.01	24.89±0.13	175.56±49.72	4.73±0.25
W1	7.26±0.02	24.87±0.12	175.78±50.44	4.82±0.25
W2	7.26±0.02	24.96±0.16	176.89±51.42	4.73±0.26
W3	7.25±0.02	24.99±0.25	174.56±49.94	4.62±0.27
W4	7.27±0.02	25.01±0.31	174.89±51.33	4.78±0.26

4 Conclusions

Feeding pellets made from BSF larvae flour had no significant effect ($p > 0.05$). It means that the pellet made from BSF larvae flour proved to be an ingredient that can be used as a raw material replacement for fish flour, which has potential to solve the farmers problem regarding to the fish flour tends to be increasingly expensive.

We would like to express our gratitude to freshwater crayfish research group and Zoology Laboratory of Biology Education Department, University of Jember, for facilitating and providing support in this research. Availability of data in this research, can be accessed with permission. The authors declare that this study has no conflict of interest. This research is supported by Research Institute, The University of Jember.

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