Nutritional Value and Growth Performance of Sea Worms (Nereis sp) Fed With Hermetia Illucens Maggot Flour and Grated Coconut (Cocos nucifera) as Naturral Feed

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Nutritional value and growth performance of sea worms (*Nereis* sp.) fed with *Hermetia illucens* maggot flour and grated coconut (*Cocos nucifera*) as natural feed

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Abstract. *Herawati VE, Pinandoyo, Windarto S, Rismaningsih N, Riyadi PH, Darmanto YS, Radjasa OK. 2020. Nutritional value and growth performance of sea worms (*Nereis *sp.) fed with* Hermetia illucens *maggot flour and grated coconut* (Cocos nucifera) *as natural feed. Biodiversitas 21: 5431-5437.* Sea worms are one of the natural feeds used for shrimp aquaculture. This study aimed to investigate the growth performance and nutritional quality of sea worms (*Nereis* sp.) fed with *Hermetia illucens* maggot flour and grated coconut (*Cocos nucifera*). *Nereis* sp. individuals were cultured at a density of 100/plastic container for 35 days, and fed twice daily with a feeding rate of 5% of the total body weight. This study used five treatments, i.e.: A. 50% maggot flour and 50% coconut grated, B. 75% maggot flour and 25% coconut grated, C. 25% maggot flour and 75% grated coconut, D. 100% maggot flour, and E. 100% coconut grated. The results showed that the sea worms fed on maggot flour and grated coconut had a significant effect ($P < 0.01$) on the survival rate (SR), feed conversion rate (FCR), and feed efficiency. Treatment D showed the highest absolute growth value, specific growth rate (SGR), feed efficiency, and SR (0.45 g, 3.25%, 49.23%, and 99.67%). Feeding rate *n* ranged from 30.50% to 34.67%, and the FCR value ranged from 2.07-2.43%. The highest nutrient contents were observed in treatment D, with 54.05% protein, 22.54% fatty acid, 55.46 ppm methionine, and 10.98% EPA. This result suggested that *Nereis* sp. fed with 100% maggot flour had the greatest nutritional quality and growth performance.

Keywords: Feed, growth, maggot, *Nereis*, nutrient

INTRODUCTION

Sea worms (*Nereis* sp.) are marine animals that usually live on the coast of tidal areas by digging into the substrate, whether it is sandy, muddy, or sandy loam. *Nereis* sp. has the potential to be developed for aquaculture (Mouneyrac 2010; Munairi 2012; Gamis et al. 2016; Asnawi 2018). The problem that arises is the availability of *Nereis* sp.; stocking for farming is still very dependent on catching marine worms in nature, which can cause a decrease in the population of marine worms. Therefore, it is necessary to cultivate marine worms that have the potential to be a source of natural feed. *Nereis* sp. has the potential to be developed into natural feed for both tiger and whiteleg shrimp. *Nereis* sp. is used as a shrimp feed because of its nutritional content, which can improve the quality of gamete cells and viability of shrimp larvae (Wibowo et al. 2019). Protein levels of 35-45%, fat levels of 10%, and several types of reproductive hormones are required in shrimp feed. The nutritional content of sea worms is quite high: the average protein content is >50%, and the average fat content is <15% (Hadiyanto 2013). Sea worms are deposit feeders that live in the substrate, and emerge in search of food (Munairi 2012). During this time, meeting the quantity of sea worms required for feed still relies on taking animals from their natural habitat (Wibowo et al. 2019). This results in a break in the food chain and a decline in the population of sea worms. The factors that determine the success of cultivation depend on the quality of the feed provided (Gamis et al. 2016).

Two types of feed with high nutritional contents are maggot and grated coconut (*Cocos nucifera*). Maggot is a source of high animal protein; it contains 30-45% protein based on the results of maggot proximate composition studies (Azir et al. 2017; Herawati et al. 2019). Grated coconut is a source of vegetable protein; according to the proximate protein analysis of Gamis et al. (2016), grated coconut comprises 14.31% protein, 6% fat, 8.4% fiber, 0.84% ash, and 57.38% water. Previous research related to the effects of using maggots as feed has been carried out in several studies, including those on carp (Herawati et al. 2019) and milkfish (Herawati et al. 2020). Previous research related to the effect of feeding showed that grated coconut meat and shrimp head flour could affect the growth of sea worms (Gamis et al. 2016). This study aimed to determine the nutritional quality and growth performance *Nereis* sp. fed with *Hermetia illucens* maggot flour and grated coconut.

MATERIALS AND METHODS

Animal test

Nereis sp. were used in the enlargement phase at two months of age, with an average weight of 0.20-0.22 g. The animals tested were kept at 100 individuals/30 L container with a maintenance time of 35 days.

Feed

The test feed used was maggot flour. The maggots used were 15 days old during maintenance, and were then dried and ground to a flour. Grated coconut was obtained from the market and dried.

Media

Media, in the form of a coastal mangrove sand substrate, was previously washed clean using a recirculation system with a substrate height of 10 cm and water height of 3 cm (Hermawan et al. 2015). The seawater used comes from reservoirs that have gone through a sterilization stage using 10 ppm chlorine and neutralization with 5 ppm sodium thiosulfate.

Methods

The laboratory research was conducted at Chemical Laboratory, Center for Brackish Water Cultivation Jepara, and Animal Food Science Laboratory, Faculty of Animal Husbandry and Agriculture, Universitas Diponegoro, Semarang, Indonesia.

The study was conducted experimentally with a completely randomized design, using four treatments and three replicates of each. Treatment A: 50% maggot flour and 50% grated coconut; treatment B: 75% maggot flour and 25% grated coconut; treatment C: 25% maggot flour and 75% grated coconut; treatment D: 100% maggot flour; and treatment E: 100% grated coconut. The feed was provided in the morning and evening. The feed was given at a fixed feed rate of 5% of the biomass (Hartanti and Suyono 2015). Feeding was performed by reducing the water level to about 1 cm from the substrate surface.

Proximate analysis of the protein content of maggot meal and grated coconut was 52.79% and 15.26%. Maggot meal has 22.53% higher protein content for the fat content, which was 30.26% for and 25.14% for grated coconut (Table 1). Fatty acid profile of maggot meal and grated coconut as feed on the post-larvae shrimp presented in Table 2.

The highest fatty acid profile analysis of maggot meal was in Linoleic fatty acids, which was 6.83%, while the highest fatty acid profile for grated coconut was in EPA fatty acids, which was 9.13%. The amino acid profile of maggot meal and grated coconut as feed for *Nereis* sp. was presented in Table 3. The highest amino acid profile of maggot meal was lysine of 48.57 ppm, and grated coconut was valine 28.87ppm.

Absolute growth (W_m)

Absolute growth (W_m), known based on the average biomass of sea worms (*Nereis* sp.) calculated using the following formula (Tacon 1993).

Table 1. Proximate analysis of maggot meal and grated coconut as feed (in %, dry weight)

Contents (%)	Natural feed	
	Maggot meal	Grated coconut
Protein	52.79	30.26
Fat	15.26	25.14
Ash	11.25	15.20
Crude fiber	10.63	18.93
Nitrogen-free extract	10.07	10.47
Total	100.00	100.00

Table 2. Fatty acid profile of maggot meal and grated coconut

Fatty acids profile (%)	Maggot meal	Grated coconut
Myristic	1.92 ± 0.05	0.48 ± 0.09
Pentadecanoic	1.09 ± 0.06	1.15 ± 0.08
Palmitic	4.14 ± 0.09	4.59 ± 0.04
Stearic	2.51 ± 0.07	2.91 ± 0.09
Oleic/ω9	3.07 ± 0.02	2.61 ± 0.01
Linoleic/ω6	6.83 ± 0.09	7.07 ± 0.02
Linolenic/ω3	4.54 ± 0.05	5.32 ± 0.01
Arachidonic	0.07 ± 0.02	0.13 ± 0.08
DHA	1.03 ± 0.05	6.23 ± 0.03
EPA	5.05 ± 0.02	9.13 ± 0.08

Table 3. Amino acids profile of maggot meal and grated coconut as feed for *Nereis* sp.

Amino acids (ppm)	Maggot meal	Grated coconut
Aspartic acid	38.92±0.08	23.94±0.01
Serine	15.61±0.03	17.62± 0.01
Glutamic acid	36.61±0.04	22.37±0.07
Glycine	19.36±0.04	19.19±0.01
Histidine	9.78±0.03	19.70±0.01
Arginine	20.51±0.04	27.28±0.01
Threonine	19.02±0.09	20.37±0.01
Alanine	40.65±0.05	22.51±0.09
Proline	20.25±0.05	19.00±0.06
Valine	30.24±0.05	28.87±0.04
Methionine	21.10±0.08	21.40±0.04
Lysine	48.57±0.04	24.16±0.01
Isoleucine	19.97±0.03	12.79±0.04
Leucine	32.44±0.05	26.88±0.05
Phenylalanine	15.49±0.07	15.98±0.10

$$W_m = W_t - W_0$$

Where W_m is absolute growth average of test animals (g), W_t is average weight of test animals at the end of the study (g), and W_0 is average weight of test animals at the beginning of the study (g).

Specific growth rate (SGR)

The specific growth rate is calculated by the formula (Tacon 1993) as follows:

$$SGR = \frac{\ln W_t - \ln W_0}{t} \times 100\%$$

Where SGR is specific growth rate (%), W_t is average sea worms' weight at the end of the study (g), and W_0 is average sea worms' weight at the beginning of the study (g).

Feed consumption rate

Feed Consumption Rate is the amount of feed consumed by sea worms, calculated from the total feed given during fish rearing (Tacon 1993).

Efficiency of feed utilization (EFU)

The efficiency of feed utilization is calculated using the formula (Tacon 1993) as follows:

$$EFU = \frac{W_t - W_0}{F} \times 100\%$$

Where EFU is Efficiency of Feed Utilization (%), W_t is final biomass at the end of the study (g), W_0 is initial biomass at the beginning of the study (g), and F is total feed consumed during the study.

Feed conversion ratio (FCR)

Feed Conversion Ratio (FCR) is the value of the given feed efficiency. Feed conversion ratio using the formula (Tacon, 1993).

$$FCR = \frac{F}{(W_t + D) - W_0}$$

Where FCR is feed conversion ratio, F is amount of feed given (g), W_t is weight of fish biomass at time t (g), W_0 is weight of fish biomass at the beginning of maintenance (g), and D is weight of dead fish biomass during maintenance (g).

Survival rate (SR)

The survival rate formula based on Tacon (1993):

$$SR = \frac{N_t}{N_0} \times 100\%$$

Where SR is Survival Rate (%), N_t is the number of individuals at the end of the study, and N_0 is the number of individuals at the beginning of the study.

Proximate analysis

The proximate chemical composition of the samples was determined using a standard procedure (Herawati et al. 2019). The crude protein content was calculated by multiplying the total nitrogen factor. The difference estimated the carbohydrate content.

The essential amino acid profile

The amino acid composition of the sample was determined using High-Performance Liquid Chromatography (HPLC) (Shimadzu LC-6A, Japan) (Herawati et al. 2019).

Fatty acid profile

The fatty acid composition of the sample was determined using a gas chromatograph (Shimadzu, Japan) (Herawati et al. 2019).

Water quality

The parameters of water quality in sea worm maintenance media for 35 days are presented in Table 4.

Table 4. Water quality parameters of the media for 35 days

Variable	Range	References
DO (mg/L)	5.6-6.7	4.20-9.40*
pH	7.6-8.2	7.0-8.5**
Temperature (^{0}C)	28-31	25-31**
Salinity	29-31	5-35*

Note: *Wibowo et al. (2019), **Hermawan et al. (2019)

Data analysis

The analyzed data included the absolute growth, feed consumption rate, efficiency of feed utilization (EFU), feed conversion ratio (FCR), specific growth rate (SGR; or daily growth rate), survival rate (SR; or survival), and nutrition of *Nereis* sp. The results obtained were further descriptively analyzed by statistical tests and presented in graphical form. The data obtained were then analyzed statistically by testing for normality, homogeneity, and additivity. Data that were normal, homogeneous, and additive were then subjected to analysis of variance (ANOVA). ANOVA test results showing real differences were then analyzed using Duncan multiple range test.

RESULTS AND DISCUSSION

Results

Based on research that has been done for 35 days, the average value calculation results are presented in Table 5.

Table 5. Average value of absolute growth, SGR, feed consumption rate, EFU, FCR and SR sea worm (*Nereis* sp.) for 35 maintenance days

Variable	Treatments				
	A	B	C	D	E
Absolute Growth (g)	0.32±0.04^{abc}	0.38±0.02^{d}	0.25±0.02^{a}	0.45±0.01^{d}	0.28±0.0007^{ab}
SGR (%)	2.79±0.12^{ab}	2.97±0.11^{bc}	2.50±0.40^{a}	3.25±0.03^{d}	2.59±0.12^{ab}
Feed Consumption Rate (%)	35.04±1.39^{bcd}	34.35±1.26^{bcd}	32.80±0.96^{bcd}	30.50±1.53^{d}	34.67±1.49^{bcd}
EFU (%)	28.25±2.44^{a}	39.87±2.76^{bc}	31.61±10.2^{ab}	49.23±2.15^{d}	33.75±0.02^{ab}
FCR	2.43±0.26^{a}	2.40±0.38^{c}	2.30±0.79^{ab}	2.07±0.30^{d}	2.33±0.19^{abc}
SR (%)	92.33±2.52^{a}	98.33±0.58^{bc}	98.67±1.15^{bcd}	99.67±0.58^{bcd}	98.33±1.53^{bcd}

Note: A. Feed 50% maggot flour and 50% grated coconut, B. Feed 75% maggot flour and 25% grated coconut, C. Feed maggot flour 25% and grated coconut 75%, D. Feed 100% maggot flour, E. Feed 100% grated coconut

The highest absolute growth value, specific growth rate, feed consumption rate, and the highest efficiency of feed utilization was treatment D (0.40%; 0.85%; 36.50% and 1.51%). The lowest value is Absolute growth, specific growth, feed consumption level and feed utilization efficiency in the treatment of *Nereis* sp. was treatment C (0.25%; 0.25%; 32.80% and 0.29%).

The ANOVA results for the absolute weight value of *Nereis* sp. showed that feeding with maggot flour and grated coconut during the study had a significant effect ($P < 0.05$) on absolute growth ($F_{count} > F_{table}$). Based on the results of Duncan's multiple range test, the absolute weight value of *Nereis* sp. in treatment D was not significantly different from that in treatment B but was significantly different from those in treatments C, E, and A.

The results of various analyses of the SGR values of *Nereis* sp. showed that feeding with maggot flour and grated coconut during the study had a significant effect ($P < 0.05$) because of the value of $F_{count} > F_{table}$ of the SGR. Based on the results of Duncan's multiple range test, the SGR values of *Nereis* sp. in treatment D were very significantly different from those in treatments A, B, C, and E.

The results of the feed consumption rate analysis of *Nereis* sp. showed that feeding with maggot flour and grated coconut had a significant effect ($P < 0.05$) ($F_{count} > F_{table}$). Based on the results of Duncan's multiple range test, the SGR values of *Nereis* sp. were significantly different in treatment D than in treatments A, B, C, and E.

The results of the analysis of various values of the feeding efficiency of *Nereis* sp. showed that the feeding of maggot flour and grated coconut during the study had a significant effect ($P < 0.05$) ($F_{count} > F_{table}$). Based on the results of Duncan's multiple range test, the *Nereis* sp. feed efficiency utilization in treatment D was significantly different from those in treatments A, B, C, and E.

The ANOVA results for the FCR of *Nereis* sp. showed that feeding with maggot flour and grated coconut during the study had a significant effect ($P > 0.05$) ($F_{count} > F_{table}$). Based on the results of Duncan's multiple range test, the FCR values in treatment A were not significantly different from those in treatments C and E but were significantly different from those in treatment B and very significantly different from those in treatment D.

The results of the analysis of SR values of *Nereis* sp. showed that feeding with maggot flour and grated coconut had a significant effect ($P < 0.05$) because of the value of $F_{count} > F_{table}$ SR. Based on the results of Duncan's multiple range test, the SGR values of *Nereis* sp. in treatment D were not significantly different from those in treatments C, B, and E, but were very significantly different from those in treatment A.

The highest results of the analysis of the nutritional quality of protein and fat of *Nereis* sp. with the feeding of maggot flour 100% (D), namely 54.05% and 22.54%, respectively. The lowest nutritional content of protein and fat was *Nereis* sp. with Maggot flour feed 25% and grated coconut 75 (C), which were 48.16% and 18.59%, respectively. Nutritional value of sea worms (*Nereis* sp.) for 35 maintenance days is presented in Table 6.

The highest amino acid profile was in *Nereis* sp. by feeding maggot flour 100% (D) with the highest methionine of 55.46 ppm. The lowest amino acid profile was in *Nereis* sp. with Maggot flour 25% feed and grated coconut 75 (C) with tryptophan as much as 3.92 ppm. The results of the analysis of the total amino acid profile of the results of the analysis of amino acids sea worms (*Nereis* sp.) For 35 Maintenance Days are presented in Table 7.

The highest fatty acid profile was in *Nereis* sp. by feeding maggot flour 100% (D) with the highest EPA, 10.98%. The lowest fatty acids profile was in *Nereis* sp. with Maggot flour feed 25% and grated coconut 75 (C) with EPA essential fatty acids as much as 3.88%. The results of the analysis of the fatty acids of sea worms (*Nereis* sp.) for 35 maintenance days are presented in Table 8.

Discussion

Factors The factors that determine the success of aquaculture are feed type and quality (Gamis et al. 2016). Based on the results of previous studies, maggot flour and grated coconut have a very significant effect ($P < 0.01$) on the feed utilization efficiency, feed consumption rate, FCR, and SR; and a significant effect ($P < 0.05$) on the absolute growth and SGRs.

Regarding the absolute growth and SGRs of *Nereis* sp., the treatment with 100% maggot flour (D) produced the highest values, at 0.45 ± 0.01 g and 3.25%, respectively. The treatment with 25% maggot flour and 75% grated coconut (C) produced the lowest values, with an absolute growth of 0.25 g and specific growth rate of 2.5%. These results are because the 100% maggot flour feed had the most appropriate nutritional content for the growth of sea worms. Feeds that contain animal proteins can be efficiently utilized and are more easily digested by sea worms. (Rasidi and Patria 2012). The high amount of fat in maggot flour is used both as an energy source and for growth. Maggot flour contains 40-50% protein and 30% fat, as well as amino acids such as cysteine, histidine, tryptophan, and tyrosine (Herawati et al. 2020).

Table 6. Nutritional value of sea worms (*Nereis* sp.) for 35 maintenance days

Proximate	*Nereis* sp. before treatment (%)	*Nereis* sp. after treatments (%)				
		A	B	C	D	E
Protein	33.19± 004	50.65± 0.03	51.12± 0.03	48.16± 0.06	54.05± 0.05	49.77± 0.08
Fat	19.98± 0.03	21.04± 0.09	22.22± 0.02	18.59± 0.04	22.54± 0.02	20.84± 0.03
Crude fiber	15.89± 0.02	14.25± 0.07	10.92± 0.07	15.82± 0.02	10.39± 0.05	16.25± 0.02
Ash	15.57± 0.04	7.18± 0.09	8.61± 0.01	8.83± 0.08	6.99± 0.02	8.18± 0.01
Carbohydrate	15.37± 0.01	6.88± 0.01	6.83± 0.02	8.6± 0.01	6.03± 0.01	10.61± 0.02

Note: A. Feed 50% maggot flour and 50% grated coconut, B. Feed 75% maggot flour and 25% grated coconut, C. Feed maggot flour 25% and grated coconut 75%, D. Feed 100% maggot flour, E. Feed 100% grated coconut

Table 7. Results of amino acid analysis of sea worms (*Nereis* sp.) for 35 maintenance days

Amino Acid (ppm)	*Nereis* sp before treatment	A	B	C	D	E
L Histidine	9.96± 0.04	13.96 ± 0.04	16.28 ± 0.02	13.32 ± 0.08	20.07 ± 0.04	16.07 ± 0.04
L-Threonine	12.30 ± 0.03	20.30 ± 0.03	26.75 ± 0.04	19.30 ± 0.05	27.48± 0.06	24.48 ± 0.04
L-Proline	10.79 ± 0.01	20.79 ± 0.01	25.38 ± 0.02	20.59 ± 0.03	28.49 ± 0.04	24.49 ± 0.03
L-Tyrosine	8.63 ± 0.03	20.63 ± 0.03	25.20 ± 0.03	19.23 ± 0.02	27.79 ± 0.03	23.76 ± 0.05
L-Leucine	12.93 ± 0.01	32.93 ± 0.01	34.47 ± 0.02	30.93 ± 0.05	36.12 ± 0.02	36.12 ± 0.03
L-Aspartate	14.04 ± 0.04	31.04 ± 0.04	29.25 ± 0.02	30.04 ± 0.06	44.68 ± 0.03	34.68 ± 0.01
L-Lysine	7.99 ± 0.06	22.99 ± 0.06	19.19 ± 0.03	20.99 ± 0.03	24.30 ± 0.02	24.30 ± 0.01
Glycine	16.99 ± 0.01	36.99 ± 0.01	41.50 ± 0.04	34.99 ± 0.02	48.61 ± 0.03	44.61 ± 0.03
L-Arginine	6.41 ± 0.03	9.41 ± 0.03	7.749 ± 0.03	7.41 ± 0.03	9.71 ± 0.01	9.71 ± 0.03
L-Alanine	25.49 ± 0.03	36.49 ± 0.03	34.90 ± 0.04	30.49 ± 0.09	40.88 ± 0.03	38.81 ± 0.01
L-Valin	11.64 ± 0.03	21.65 ± 0.03	23.34 ± 0.03	19.65 ± 0.06	28.37 ± 0.01	23.37 ± 0.01
L-Isoleucine	14.81 ± 0.02	19.81 ± 0.02	21.18 ± 0.05	15.81 ± 0.01	26.34 ± 0.01	21.34 ± 0.02
L-Phenylalanine	16.33 ± 0.04	26.33 ± 0.04	29.46 ± 0.04	22.93 ± 0.04	35.15 ± 0.05	30.15 ± 0.05
L-Glutamic Acid	26.15 ± 0.04	56.15 ± 0.04	52.78± 0.04	52.75 ± 0.04	69.14 ± 0.04	64.14 ± 0.04
L-Serin	11.18 ± 0.01	21.18 ± 0.01	23.21 ± 0.02	18.98 ± 0.01	28.53 ± 0.04	24.53 ± 0.03
L-Tryptophan	4.72 ± 0.04	4.72 ± 0.04	5.53 ± 0.04	3.92 ± 0.04	8.98 ± 0.06	4.98 ± 0.04
L-Methionine	18.26 ± 0.03	38.26 ± 0.03	49.56 ± 0.02	32.26 ± 0.03	55.46 ± 0.04	40.37 ± 0.03
L-cystine	12.34 ± 0.04	16.34 ± 0.04	15.62 ± 0.04	15.32 ± 0.04	21.60 ± 0.04	18.60 ± 0.04

Note: A. Feed 50% maggot flour and 50% grated coconut, B. Feed 75% maggot flour and 25% grated coconut, C. Feed maggot flour 25% and grated coconut 75%, D. Feed 100% maggot flour, E. Feed 100% grated coconut

Table 8. Results of analysis of fatty acids in sea worms (*Nereis* sp.) for 35 maintenance days

Fatty acids (%)	*Nereis* sp before treatment	A	B	C	D	E
C 6: 0	0.12 ± 0.05	0.32 ± 0.05	0.37 ± 0.01	0.37 ± 0.01	0.47 ± 0.09	0.30± 0.05
C 8: 0	0.25 ± 0.01	0.35 ± 0.01	0.52 ± 0.08	0.79 ± 0.01	1.59 ± 0.01	0.75 ± 0.01
C 10: 0	0.17 ± 0.03	0.17 ± 0.03	0.19 ± 0.01	0.18 ± 0.01	1.36 ± 0.04	0.27 ± 0.03
C 11: 0	0.29 ± 0.04	0.29 ± 0.04	0.33 ± 0.01	0.28 ± 0.01	0.38 ± 0.02	0.31 ± 0.04
C12: 0	2.10 ± 0.01	3.19 ± 0.01	3.79 ± 0.02	2.01 ± 0.04	4.45 ± 0.01	2.79 ± 0.01
C 13: 0	0.75 ± 0.03	0.75 ± 0.03	0.12 ± 0.01	0.12 ± 0.02	2.42 ± 0.04	0.95 ± 0.03
C 14: 0	1.57 ± 0.03	1.57 ± 0.03	1.98 ± 0.01	1.88 ± 0.02	2.68 ± 0.04	1.33 ± 0.03
C 14: 1	0.77 ± 0.01	0.77 ± 0.01	0.27 ± 0.01	0.17 ± 0.01	1.79 ± 0.01	0.89 ± 0.01
C 15: 0	0.51 ± 0.03	0.51 ± 0.03	0.63 ± 0.03	0.49 ± 0.05	0.98 ± 0.03	0.51 ± 0.03
C 16: 0	3.79 ± 0.01	3.79 ± 0.01	4.53 ± 0.03	3.63 ± 0.04	5.67 ± 0.03	2.89 ± 0.01
C 16: 1	0.15 ± 0.05	0.37 ± 0.05	0.38 ± 0.01	0.39 ± 0.04	0.65 ± 0.03	0.17 ± 0.05
C 17: 0	0.13 ± 0.04	1.13 ± 0.04	0.57 ± 0.04	0.12 ± 0.01	3.52 ± 0.04	0.83 ± 0.04
C 18: 0	0.02 ± 0.04	1.67 ± 0.04	1.86 ± 0.01	0.99 ± 0.01	0.93 ± 0.02	0.67 ± 0.04
C 18: 1	0.55 ± 0.04	1.58 ± 0.04	2.58 ± 0.04	1.88 ± 0.01	2.98 ± 0.03	0.98 ± 0.04
C 18: 2	1.01 ± 0.01	1.18 ± 0.01	2.43 ± 0.04	1.13 ± 0.03	4.53 ± 0.05	1.35 ± 0.01
C 18: 3	0.04 ± 0.03	0.45 ± 0.03	4.37 ± 0.02	1.35 ± 0.03	6.55 ± 0.04	1.45 ± 0.03
C 20: 0	0.16 ± 0.05	0.39 ± 0.05	0.48 ± 0.04	0.37 ± 0.02	0.44 ± 0.06	0.19 ± 0.05
C 20: 1	0.12 ± 0.04	0.67 ± 0.04	0.58 ± 0.03	0.55 ± 0.01	0.96 ± 0.04	0.47 ± 0.04
C 20: 2	0.34 ± 0.02	0.79 ± 0.02	0.98 ± 0.02	0.98 ± 0.03	1.78 ± 0.04	0.69 ± 0.02
C 20: 4	0. 15 ± 0.04	0.55 ± 0.04	0.64 ± 0.05	0.69 ± 0.01	0.98 ± 0.04	0.55 ± 0.04
EPA	2.04 ± 0.05	5.09 ± 0.05	7.68 ± 0.02	3.88 ± 0.01	10.98 ± 0.01	6.09 ± 0.05
DHA	1.63 ± 0.02	3.68 ± 0.02	5.58 ± 0.03	2.35 ± 0.03	7.36 ± 0.03	4.68 ± 0.02

Note: A. Feed 50% maggot flour and 50% grated coconut, B. Feed 75% maggot flour and 25% grated coconut, C. Feed maggot flour 25% and grated coconut 75%, D. Feed 100% maggot flour, E. Feed 100% grated coconut

In comparison, the proximate protein analysis of grated coconut found that it contained 14.31% protein, 6% fat, 8.4% fiber, 0.84% ash, and 57.38% water (Gamis et al. 2016). This balance of dietary fat and protein increases the growth of sea worms (Rasidi 2012). According to Gamis et al. (2016), one of the factors that determine the success of *Nereis* sp. aquaculture is the quality of the feed provided.

The use of 100% maggot flour feed produced the highest values, with an absolute growth of 0.45 g and a specific growth rate of 3.25% within the maintenance period of 35 days. The results of this study were better than those of the study conducted by Gamis et al. (2016), in which the absolute growth value of *Nereis* sp. fed grated coconut for 60 days was 0.42 g; and lower than those of the study by Rasidi and Patria (2012), in which the highest absolute weight was 1.01 g with a treatment in the form of chicken intestine flour feed for 50 days. The growth rate in this study was higher than that reported by Gamis et al.

(2016), in which the growth rate of sea worms fed 100% grated coconut for 60 days was 0.131%; and Rasidi and Patria (2012), in which the growth rate of sea worms fed intestinal flour for 50 days was 1.76%.

Maintenance of sea worms for 35 days with 100% maggot flour (D) showed the lowest feed consumption rate (30.50%), which was inversely proportional to the absolute growth value and growth rate. This indicated that 100% maggot flour can be easily digested and has the nutrient content required by *Nereis* sp. to reduce feed costs, as well as high energy owing to its high protein and fat contents. The amount of feed given in relation to the FCR did not have a significant effect ($P > 0.05$) on the growth of sea worms; the lowest FCR in *Nereis* sp. was found to occur with 100% maggot flour feed (2.07). The lower the FCR, the higher the EFU. The FCR is the ratio between the amount of food given and weight gained; the lower the FCR value, the more efficient the animal increases its body weight. The FCR values in this study were higher than those found in Rasidi and Patria (2012), with an FCR of 0.65-1.63, and Gamis et al. (2016), with an FCR of 1.72-3.27.

The highest feed efficiency in *Nereis* sp. was found in the 100% maggot flour treatment (D; 49.23%) and the lowest was found in the 50% maggot flour and 50% grated coconut treatment (A; 28.25%). From the results of the ANOVA, the EPP value had a significant effect ($P < 0.01$). This is because the maggot flour is absorbed by the sea worm's body effectively and efficiently, and can therefore be 100% utilized for growth. The feed efficiency is influenced by the nutrition source and the amount of each nutrition source in the feed (Herawati et al. 2020). According to Rasidi and Patria (2012), feed efficiency can affect growth.

The results of the proximate analysis are shown in Table 6. The results of the study showed that there were differences in each treatment. *Nereis* sp. fed 100% maggot flour (D) had the highest protein and fat contents, at 54.05% and 22.54%, corresponding to 20.86% and 2.56% increases, respectively. The lowest nutrient contents were found in the 25% maggot flour and 75% grated coconut treatment (C), with 48.16% protein and 18.59% fat. The results of this study are reinforced by the statement of Rasidi and Patria (2012) that the growth rate shows the quality of feed provided; sea worms more easily digest nutrients from animal protein-sourced feed. Sources of fat in feed can also be used as an energy source and used for growth. *Nereis* sp. is the best live feed for shrimp; its high fatty acid content is ideal for ovarian growth and development. The fat content required by shrimp is 10% (Nguyen 2011). Fat is an important nutrient in the development of shrimp ovaries (Tocher 2015).

The amino acid profile results (Table 3) showed that treatment D gave the highest amino acid content, at 55.46 ppm up from 37.2 ppm, and increase of 18.26%. The lowest amino acid content was found in C (32.26 ppm). The function of the essential amino acid methionine is to improve the balance and use of other amino acids to increase growth; it is essential for protein synthesis and other physiological functions. Methionine and cysteine are the primary sources of amino acid sulfate for animals; however, cysteine is not essential because it can be synthesized from methionine (Bhagavan, 1992). The body needs methionine for the formation of nucleic acids and synthesis of tissues and proteins. In addition, it forms other amino acids (cysteine) and vitamins (choline). Methionine works with vitamin B12 and folic acid to help the body to regulate excessive protein in a high-protein diet. The methionine requirement for fish feed is 2.30%.

The synthesis of tissue proteins is mostly determined by the completeness and level of amino acids that enter or are transported into tissue cells. The synthetic process that takes place in the ribosome is very dependent on the presence of amino acids picked up by DNA and translated into the tissue (Rolland et al. 2015). The efficiency and magnitude of protein synthesis in tissue cells are greatly influenced by the completeness and balance of amino acids circulating and being translated into the tissue. Methionine is needed by fish to initiate protein synthesis and can affect muscle growth (Belghit 2014). It has been proven that the addition of methionine to the feed increases the growth and immune response (Yuan et al. 2011; Kuang et al. 2012; Boonyoung et al. 2013; Ma et al. 2013; Rolland et al. 2015). Methionine deficiency can cause decreased growth and survival in turbot (*Psetta maxima*) (Ma et al. 2013) and cobia (*Rachycentron canadum*) and cause cataracts in rainbow trout [*Oncorhynchus mykiss* (Walbaum)] (Boonyoung et al. 2013).

The highest total fatty acid profile was found in treatment D (10.98%), and the lowest was found in treatment C (3.88%) (Table 4). Monounsaturated fatty acids and polyunsaturated fatty acids, including omega-3 fatty acids (EPA and DHA), play a role in reducing triacylglycerol levels and increasing the excretion process. They also increase the fluidity of cell membranes, forming eicosanoids that reduce platelets, and play an essential role in brain and retinal development. Fatty acids also play an essential role in the maturation process of the parent gonad to produce high-quality eggs; they are important factors that must be considered when providing shrimp feed during the gonad ripening process.

The SRs of *Nereis* sp. during 35 days of feeding with grated coconut and maggot flour was significantly high (94.00-99.67%), with the highest being found in those fed 100% maggot flour and the lowest in those fed 50% maggot flour and 50% grated coconut (A). The results of this study were higher than those of Rasidi and Patria (2012), in which the SRs of *Nereis* sp. fed chicken intestine flour, blood meal, and shrimp head flour were 80.56-92.22%; and those of Gamis et al. (2016), in which the SR of *Nereis* sp. fed with 100% grated coconut was 96.3%. The high SRs in this study shows that the quality and quantity of feed provided is sufficient to meet basic needs and can even increase growth. This is because the feed provided can be digested effectively and can support marine worm survival. The survival of sea worms can also be influenced by the cultivation media (Rasidi and Patria 2012).

The results of this study showed that the best treatment to support the cultivation of *Nereis* sp. was treatment D

(100% maggot meal). This was because 100% maggot flour has the most appropriate nutrient content for sea worms. According to Costa et al. (2000) and Rasidi and Patria (2012), a single feed is capable of supporting *Nereis* sp. survival. Maggot flour is a source of animal protein (Herawati et al. 2019); one alternative that can be used as feed in aquaculture is animal protein-containing feed (Rasidi and Patria 2012).

In conclusion, 100% maggot flour showed the highest absolute growth value, SGR, feed efficiency, and SR (0.45g, 3.25%, 49.23%, and 99.67%), while the total feed consumption ranged from 30.50% to 34.67%, and the FCR value ranged from 2.07-2.43%. The nutrient contents of *Nereis* sp. in treatment D were 54.05% protein, 22.54% fatty acids, 55.46 ppm methionine, and 10.98% EPA.

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