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The Effects of Substitution on Fish Meal with Maggot Meal in Artificial Feed for Eels (*Anguilla bicolor*) Growth and Survival Rate

Ananda Ahmad Mahitala*, Purnama Sukardi, Dewi Nugrayani, Laela Trianingtyas

Department of Aquaculture, Faculty of Fisheries and Marine Sciences, Jenderal Soedirman University, Purwokerto 53122, Central Java, Indonesia.

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Correspondence
anandaahmad36@gmail.com

Abstract

Eel (*Anguilla* sp.) is a leading freshwater fish commodity. In the intensive system, high stocking density results in high production costs. Maggot meal is an alternative raw material that has complete nutritional value such as fish meal but is cheaper. The purpose of this study was to determine the effectiveness of substituted fish meal with maggot meal on the growth and survival rate (*Anguilla bicolor*) Elver phase. The method carried out in this study used an experimental method with a completely randomized design (CRD) consisting of 4 treatments and 3 replications with a combination of fish meal and maggot meal, P_0: 100% TI and 0% TM, P_1: 80% TI and 20% TM, P_2: TI 60% and TM 40% and P_3: TI 40% and TM 60%. The results of rearing for 60 days showed a significant effect on absolute weight growth, specific growth rate, and yield, while the yield had no significant effect on absolute length growth, feed conversion, and survival. The results of the water quality parameters of the media are temperatures ranging from 24 ℃ -29,8 ℃, pH ranging from 5,14-7,7, DO ranging from 2,4 mg/l – 5,1 mg/l and ammonia ranging from 0 ppm – 0,01 ppm.

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Introduction

Eel (*Anguilla sp.*) is a leading freshwater fish commodity. The advantages of eel include tasty meat, high essential fatty acids, and rich benefits for the body (Toiba *et al.*, 2022). The demand for eels in the international market has reached 300,000 tons/year. The production capacity of eel in Indonesia is projected to reach 120,000 tons, but the actual production is only 10,000 tons or about 8.33% of the total capacity (Ministry of Marine and Fisheries, 2017).

The large market demand for eel needs to be met with a large quantity of aquaculture production, so intensive fish farming is needed. Eel farmers usually start intensive rearing in the elver phase, which is included in the rearing stage. Elver is a phase between the glass eel and fingerling so that in the elver phase there is a feed transition from using natural feed to artificial feed (Jamaluddin *et al.*, 2018). In intensive fish farming, the use

of stocking densities and high feed doses results in high production costs. Feed also has a strategic role in fish cultivation, this is because the cost of buying feed can reach 60-80% of the total production cost (Priyadi, 2008).

Most of the raw materials for artificial feed in Indonesia are obtained from foreign imports (Hadadi *et al*., 2007). One of the raw material needs in high-demand fisheries is fish meal, but the production of these materials has not met market needs. In addition, the high price of fish meal and its limited availability make cultivators look for solutions with alternative feeds.

Maggot meal is an alternative raw material that has complete nutritional value such as fish meal but is cheaper. In 100 grams of fish meal there is 66,72% protein, while in 100 grams of maggot meal there is 40,83% protein, 8,94% fiber, 16,59% fat, and 7,75% water content (Rumondor *et al.,* 2016). In addition, maggot meal is available in large quantities because it can be mass produced and is easy to obtain. This study aims to determine the level of substitution of fish meal with maggot meal as a protein source that can produce good growth and survival for eels.

Research on the use of maggot meal as a substitute for fish meal has been carried out on several types of fish, namely eel (*Anguilla bicolor*) (Akmal, 2019), pomfret fish (*Colossoma macropomum*) (Kardana *et al.*, 2012), catfish (*Pangasius hypothalmus*) (Panjaitan *et al.,* 2014), tilapia (*Oreochromis niloticus*) (Arifin *et al*., 2020), and white shrimp (*Litopenaeus vannamei*) (Febrianti *et al.,* 2019).

Materials and methods

Time and Places

This research was conducted in August - October 2021 for 60 days of maintenance. The place of research was carried out at Laju Banyu Semesta Farm, Bogor.

Object

The object used in this study was an elver-phase eel (*Anguilla bicolor*) with a size of 2,5 ± 0,5 grams/fish originating from Sidat Labas Farm Bogor as many as 40 fish/aquarium. A total of 480 eels used.

Research Methods

This research was carried out using a completely randomized design (CRD) consisting of 4 treatments with 3 replications so that it became 12 experimental units, namely:

a. P_0 : Feed pasta with 100% fish meal and 0% maggot meal.
b. P1 : Feed pasta with 80% fish and 20% 20% maggot meal.
c. P_2 : Feed pasta with 60% fish meal and

40% maggot meal.

d. P_3 : Feed pasta with 40% fish meal and 60% maggot meal.

This research is divided into 3 stages, namely, the preparation stage, the implementation stage, and the analysis stage. The preparatory stage is carried out to prepare eel rearing media and feed preparation by adding maggot meal according to the concentration determined in the treatment, then the implementation stage consists of raising fish and giving each feed according to the treatment. Gathering data is carried out by observing growth, survival, and water quality.

Eel rearing

Elver phase eels size 2,5 ± 0,5 g each fish with total of 40 in each aquarium were acclimatized first and adapted to fish rearing media for 3 days. The stocking density used is 1,5 – 1,75 grams/liter, so the amount of fish biomass required is 90 – 100 fish with a water volume of 60 liters. Maintenance carried out for 60 days. Water quality management is carried out by siphoning every day at 06.30 WIB. Checking water quality parameters is also carried out to determine the condition of the water. The water quality parameters measured were temperature, pH, dissolved oxygen (DO) and ammonia. Temperature water quality measurements were carried out twice a day at 07.00 and 17.00 WIB, pH was carried out once a day at 07.00 WIB, while dissolved oxygen (DO) and ammonia were measured on day 0, day 15th, day 30th, day 45th, and day 60th at 07.00 WIB.

Feeding time

Feeding twice a day at 07.00 and 17.00 WIB for each treatment. The feed was given in a FR (Feed Rate) ratio of 3% of the eel biomass.

Research Parameters

Absolute Weight Growth

Measurement of absolute body weight of eel was measured on day 0, day 30th, and day 60th of the study. According to Zonneveld *et al.* (1991) calculation of absolute weight growth (Wm) as follows:

$$\boldsymbol{Wm = Wt - W0}$$

Absolute Length Growth

Measurement of absolute body length of eel was measured on day 0, day 30th, and day 60th of the study. According to Zonneveld *et al.* (1991) calculation of absolute length growth (Pm) as follows:

$$\boldsymbol{Pm = Lt - L0}$$

Specific Growth Rate

Measurement of specific body weight growth of eel was measured on day 0, day 30th, and day 60th of the study. According to Hariati (1989), the specific/daily growth rate (SGR) of fish is calculated using the formula:

$$SGR = \frac{LnWt - LnW0}{t} \; x \; 100\%$$

Feed Conversion Ratio

Measurement of feed conversion ratio of eel was measured on day 60th of the study. According to Zonneveld *et al.* (1991) calculation of feed conversion ratio (FCR) as follows:

$$FCR = \frac{F}{(Wt + d) - W0}$$

Yield

Measurement of yield of eel was measured on day 60th of the study. According to Sukardi *et al.* (2019) calculated using the formula:

$$Yield = \frac{Total\ Fish\ Weight\ (kg)}{Aquarium\ Volume\ (m^3)}$$

Survival Rate

According to Goddard (1996), fish survival (SR) is calculated using the formula:

$$SR = \frac{Nt}{N0} \; x \; 100\%$$

The supporting parameters, namely water quality (temperature, pH, ammonia, and dissolved oxygen), and proximate content of eel feed before and after the addition of maggot meal according to each treatment dose and fish proximate content before and after treatment.

Data Analysis

Data from the research will be analyzed statistically using Analysis of Variance (ANOVA). Data from the results (ANOVA) which showed a significant effect then continued with the Tukey test. Water quality data are presented in tables, and analyzed descriptively.

Results and Discussion

Absolute weight growth

The results of the ANOVA test analysis on absolute weight growth showed that the substitution of fish meal with maggot meal in artificial feed for eels had a significant effect ($P<0.05$).

Table 1. Absolute weight growth of elver-phase eels reared for 60 days.

Treatment	Replication (g)			Average (g)
	1	2	3	
P_0	25	26,8	18,9	23,57 ± 4,14[a]
P_1	-2,6	-5,4	-1,9	-3,3 ± 1,85[b]
P_2	-2,90	5	-1,1	0,33 ± 4,14 [b]
P_3	16,6	-10,5	3,60	3,23 ± 13,55[b]

Description: Different letter notations indicate there are significant differences P0: (0%) maggot flour, P1: (20%) maggot flour, P2: (40%) maggot flour, P3: (60%) maggot flour.

Based on the results, treatment P_0 (control) with 100% fish meal showed the highest absolute weight growth value of 23,57 ± 4,14 g while the lowest value was found in treatment P_1 (maggot 20%) which was -3,30 ± 1,85 g. This is due to the different energy values and protein content of the feed. In the P_0 treatment the protein content of the feed reached 33,30% and in the P_1 treatment the protein content of the feed only reached 24,88%.

Protein is one of the components in feed that can support eel weight gain. Besides being able to increase weight, protein is also used as an energy reserve if the availability of carbohydrates and fat in the feed is lacking. Eel (*Anguilla bicolor*) species can grow well with a feed protein content of 50% and an energy content of 4022.5 kcal DE/kg (Nawir, 2015).

The results of the 60 day study (Table 1) in the P_0, P_2, and P_3 treatments proved that the daily energy needs of eels were met by the energy content of the feed, resulting in an increase in body weight. While the P_1 treatment experienced a decrease in body weight because the energy content in the feed did not meet daily energy needs. This is in accordance with Lovell's (1989) statement that energy needs for maintenance are prioritized before the remaining excess energy is used for growth.

The decrease in body weight of fish in the P_1 treatment was thought to have decreased fat levels in the body. This is because fat is used as an energy reserve if the energy content and amount of feed are not sufficient for daily needs. In accordance with Winarno's (1997) statement that fat is a more effective source of energy than protein and carbohydrates. So it can be concluded that substitution of fish meal with maggot meal up to 60% is not recommended to be given to elver phase eels if the protein content of fish meal is 42%, because treatments P_1, P_2, and P_3 (maggot) cannot provide energy values and protein content. sufficient to support the growth of eels.

Absolute length growth

The results of the ANOVA test analysis on absolute length growth showed that the substitution of fish meal with maggot meal in artificial feed for eels had no significant effect ($P>0.05$). Based on the results, treatment P_0 (control) with 100% fish meal showed the highest absolute length growth value of 0,99 ± 0,17 cm while the lowest value was found in treatment P_3 (maggot 60%) which was 0, 43 ± 0,63 cm.

Table 2. Absolute length growth of elver phase eels reared for 60 days.

Treatment	Replication (cm)			Average (cm)
	1	2	3	
P_0	1,04	0,80	1,13	0,99 ± 0,17[a]
P_1	0,11	0,63	0,66	0,47 ± 0,31[a]
P_2	0,29	0,88	0,14	0,44 ± 0,39[a]
P_3	1,16	0,06	0,07	0,43 ± 0,63[a]

Description: The same letter notation indicates there is no significant difference P0: (0%) maggot flour, P1: (20%) maggot flour, P2: (40%) maggot flour, P3: (60%) maggot flour.

Based on the results, treatment P_0 (control) with 100% fish meal showed the highest absolute length growth value of 0,99 ± 0,17 cm while the lowest value was found in treatment P_3 (maggot 60%) which was 0, 43 ± 0,63 cm.

This result presumably because there is a relationship between the allocation of feed energy for weight growth and length growth. In accordance with the statement Arief *et al.* (2011), that the elver phase eel uses energy for weight growth after experiencing length growth first to a certain length. From Table 2., there is a growth in length for all treatments although it is not significant, in contrast to Table 1. which shows weight loss because the daily energy needs are not fulfilled by energy in the feed. The energy in the feed is stored by the eel in the form of protein and fat so that there is a significant difference in weight growth. So it can be concluded that the substitution of fish meal with maggot meal (P_1, P_2, P_3) did not give a significant difference in absolute length growth.

Specific Growth Rate

The results of the ANOVA test analysis on the specific growth rate showed that the substitution of fish meal with maggot meal in artificial feed for eels had a significant effect ($P<0.05$).

Based on the results, P_0 (control) treatment with 100% fish meal the highest specific growth rate value of 0,36%. While the lowest absolute weight growth value was found in treatment P1 (maggot 20%) which was -0,06%. This result is directly proportional to the weight growth rate which indicates that P_0 treatment is better than P_1, P_2, and P_3. The difference is due to the different energy values and protein content of the feed. In the treatment P_0 the protein content of the feed reached 33,30%, P_1 only reached 24,88%, P_2 reached 30,73%, and P_3

Table 3. Specific Growth Rate of elver-phase eels reared for 60 days

Treatment	Replication (%)			Average (%)
	1	2	3	
P_0	0,37	0,40	0,29	$0,36 \pm 0,06^a$
P_1	-0,04	-0,09	-0,03	$-0,06 \pm 0,03^b$
P_2	-0,05	0,08	-0,02	$0,00 \pm 0,07^b$
P_3	0,26	-0,19	0,06	$0,04 \pm 0,22^b$

Description: Different letter notations indicate that there are significant differences P0: (0%) maggot flour, P1: (20%) maggot flour, P2: (40%) maggot flour, P3: (60%) maggot flour.

and P_3 reached 34,30%.

Protein is an important component of feed that needs to be prepared properly so that the daily protein needs of fish can be met. The need and utilization of protein in feed can be determined based on fish species, fish size, protein quality, energy content of feed, balance of nutrient content, and level of feeding (Nawir 2015). One of the important components to determine protein requirements in feed is the quality of protein from feed raw materials.

The raw materials with the highest percentage used in the fish feed were fish meal and maggot meal. The protein content in fish meal is only around 43,31% and maggot meal is around 40,83%. The quality of the fish meal is suspected to be the cause of the insufficient amount of protein in the feed for the needs of the eel. According to Fahrizal & Ratna (2018), good fish meal has a crude protein content of 58 – 68%.

The results of maintenance for 60 days (Table 3) showed a specific growth rate of treatment P_0 (control) was higher than treatment P_3 (maggot 60%). This is inversely proportional to the amount of protein content in the feed. One of the factors causing these results was the fiber content in treatment P_3 (4,99%) was higher than treatment P_0 (1,20%). The higher the maggot content in the feed, the higher the fiber content (chitin) in the feed (Priyadi *et al*., 2009)

Chitin is a crystalline fiber and is insoluble in strong acid solutions (Elieh-Ali-Komi & Hamblin 2016; Kardana *et al*., 2012). The ability of the elver-phase eel is thought to have decreased due to the addition of this maggot meal due to the chitin content which cannot be completely digested by the body. So it can be concluded that substitution of fish meal with maggot meal up to 60% is not recommended to be given to elver phase eels if the protein content of fish meal is 42%,

because treatments P_1, P_2, and P_3 (maggot) did not show higher specific growth rates better than the control treatment P_0 (Control).

Feed Conversion

The results of the ANOVA test analysis on feed conversion showed that the substitution of fish meal with maggot meal in artificial feed for elver-phase eel had no significant effect (P>0.05).

Based on the results, treatment P_1 (maggot 20%) showed the lowest conversion value of -75,40. While the highest feed conversion value was found in the P_3 treatment (maggot 60%) which was 17,71. The results of rearing for 60 days showed a high feed conversion value. According to Djajasewaka (2003), feed conversion for elver phase eels measuring 4 g ranged from 1,17 to 1,25 with a protein content of 45%. These results were thought to be due to the protein content in the feed that was not in accordance with the needs of the eel and the addition of maggot meal to the feed. Priyadi *et al*. (2009) stated that the higher the composition of maggot in the feed formulation, the higher the physical quality of the feed, because the feed more easily destroyed if given into water. Arief *et al*. (2011) stated that the quality and quantity of feed are factors that cause a high feed conversion ratio. So it can be concluded that the substitution of fish meal with up to 60% maggot meal is not recommended to be given to elver-phase eels if the protein content of fish meal is 42%, because treatments P_1, P_2, and P_3 (maggot) resulted in feed conversion that was not better than P_0 treatment.

Yield

The results of the ANOVA test analysis on yield showed that the substitution of fish meal with maggot meal in artificial feed for elver-phase eel had a significant effect (P<0.05).

Table 4. Feed Conversion of elver-phase eels reared for 60 days

Treatment	Replication			Average
	1	2	3	
P_0	8,62	8,17	11,17	9,32 ± 1,62[a]
P_1	-82,30	-36,78	-107,13	-75,40 ± 35,68[a]
P_2	-73,31	42,09	-190,63	-73,95 ±116,36[a]
P_3	13,38	-18,88	58,62	17,71 ± 38,93[a]

Description: The same letter notation indicates there is no significant difference P0: (0%) maggot flour, P1: (20%) maggot flour, P2: (40%) maggot flour, P3: (60%) maggot flour.

Table 5. Yield of elver phase eels reared for 60 days.

Treatment	Replication (g/l)			Average (g/l)
	1	2	3	
P_0	2,09	2,08	1,95	$2,04 \pm 0,08^a$
P_1	1,64	1,54	1,60	$1,59 \pm 0,05^b$
P_2	1,57	1,72	1,66	$1,65 \pm 0,07^b$
P_3	1,91	1,47	1,74	$1,70 \pm 0,22^b$

Description: Different letter notations indicate significant differences P0: (0%) maggot flour, P1: (20%) maggot flour, P2: (40%) maggot flour, P3: (60%) maggot flour. Yield of elver phase eel fish reared for 60 days.

Based on the results, P_0 treatment (control) showed the highest yield value of 2,04 g/L. While the lowest yield value was found in the P1 treatment (maggot 20%) which was 1,59 g/L.

The results show that the yield is directly proportional to the weight gain of the fish. In accordance with the statement of Ahen (2013) that the appetite for eel is higher at high yields, so that the increase in yield is in line with the increase in the specific growth rate and absolute weight growth. This is in accordance with the highest value obtained in treatment P_0 where the value of the specific growth rate is 0,36 ± 0,06% and the absolute weight growth value is 23,57 ± 4,14 g. It can be concluded that substitution of fish meal with maggot meal is not recommended to be applied to eel in the elver phase because it has not been able to provide a better yield value than the P_0 treatment (control).

Survival Rate

The non-parametric test analysis on survival showed that the substitution of fish meal with maggot meal in artificial diets had no significant effect (P>0.05) on survival rate.

Based on the result, P_0 (control) and P_1 (maggot 20%) showed the highest survival value of 100%. While the lowest survival value was found in the P_2 treatment (maggot 40%) which was 98,33%. This proves that the eels are able to live with the given feed and the water quality treatment for 60 days of maintenance. But on the other hand, eels experience slow growth and shrinkage in body weight which has been shown in Table 1 and Table 3. According to Arief *et al*. (2011), survival rate is affected by several aspects, including stocking density, feed quality, water quality, parasites or disease.

Table 6. Survival of elver-phase eels reared for 60 days

Treatment	Replication (%)			Average (%)
	1	2	3	
P_0	100	100	100	100 ± 0^a
P_1	100	100	100	100 ± 0^a
P_2	95	100	100	$98{,}33 \pm 2{,}89^a$
P_3	100	100	9,75	$99{,}17 \pm 1{,}44^a$

Description: The same letter notation indicates there is no significant difference P0: (0%) maggot flour, P1: (20%) maggot flour, P2: (40%) maggot flour, P3: (60%) maggot flour.

Water quality

Based on the results of water quality for 60 days of maintenance, the temperature ranged from 24 °C – 29,8 °C, pH ranged from 5,14 – 7,7, DO ranged from 2,4 mg/l – 5,1 mg/l and ammonia ranged from 0 ppm – 0,01 ppm. The highest temperature value obtained was 29,8 °C and the lowest was 24 °C. The temperature of the eel rearing media fluctuated in the range of 5 °C. This is because the research location is at an altitude of 700 masl so that in the morning the temperature decreases and in the afternoon the temperature increases. However, the temperature range is normal, in accordance Safitri (2014) which states that the optimal temperature for eel growth is 28 - 30°C.

The pH of the eel rearing medium water ranged from 5,14 to 7,7. The pH value decreased to 5,14 allegedly caused by the addition of ketapang leaf extract. Ketapang leaf extract has a fairly acidic pH of 4, so that when given to the maintenance medium there will be a decrease in the pH value. However, this value does not cause death and this value is included in the optimum range. The optimum pH value for eel rearing media ranges from 6 - 8 (Ritonga, 2014).

Dissolved oxygen of eel rearing media ranged from 2,4 mg/L – 5,1 mg/L. This value can still be tolerated by eel as research by Safitri (2014), the lowest oxygen value of 2,0 mg/L eel can carry out metabolic functions normally. Ahen (2013) also stated that the dissolved oxygen value >3 mg/L was the normal range for the maintenance of eel.

Ammonia of the media for 60 days ranged from 0 – 0,01 mg/l. This ammonia value does not cause death in eels due to adaptation. Fish adaptation to high ammonia levels can be done gradually and takes time. If fluctuations in ammonia levels in the rearing medium increase little by little, fish will adapt to adjust the transport of oxygen

Table 7. Water Quality Parameter

Parameter	Range	Standard Quality	Reference
Temperature	24 °C -29,8 °C	26,91°C - 29,04°C	(Samsundari & Wirawan, 2013)
pH	5,14 -7,7	7 –8	(Samsundari & Wirawan, 2013)
DO	2,4 mg/l -5,1 mg/l	3 -5 mg/l	(Zonneveld, 1991).
Ammonia	0 mg/l – 0,01 mg/l	<1 mg/l	(Idris, 2016).

and ammonia through the gills.

Conclusion

Substitution of fish meal with maggot meal in artificial feed for Eel (*Anguilla bicolor*) Elver phase showed that the absolute weight growth, absolute length growth, specific growth rate, yield, and feed conversion were not good when compared to feeds that were only contain protein source from fish meal alone. In the other hand, the survival rate results were good for both treatment.

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References

Ahen, H. P. (2013). Kelangsungan dan Pertumbuhan Benih Ikan Sidat Anguilla marmorata Ukuran 1 Gram Pada Sistem Resirkulasi dengan Padat Penebaran Berbeda. Skripsi. Departemen Budidaya Perairan, Fakultas Perikanan dan Ilmu Kelautan, Institut Pertanian Bogor, Bogor.

Akmal, N. H. (2019). Pemanfaatan Black Soldier Fly (*Hermetia illucens*) (Linnaeus) Sebagai Alternatif Pakan Ternak Ikan Sidat (*Anguilla bicolor*) (McClelland) Fase Elver. Skripsi. Departemen Pendidikan Biologi, Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam, Universitas Pendidikan Indonesia, Bandung.

Arief, M., Pertiwi, D. K., & Cahyoko, Y. (2011). Effect Of Artificial Feed,

Natural Feed and Combination Between Them to Growth Rate, Food Convertion Ratio and Survival Rate of Indonesian Shortfin Eel (*Anguilla bicolor*). *Jurnal Ilmiah Perikanan Dan Kelautan*, 3(1), 61– 66. https://doi.org/10.20473/jipk.v3i1.116

Arifin, M., Widodo, A., Fauziah, A., & Halim, A. M. (2020). Pengaruh substitusi tepung magot (*Hermetia illucens*) terhadap pertumbuhan dan status kesehatan ikan (*Oreochromis niloticus*). *Jurnal Penelitian Chanos Chanos*, *18*(2), 83-91. http://ejournal-balitbang.kkp.go.id/index.php/chanos2

Djajasewaka, H. (2003). Pengaruh pemberian pakan buatan dalam bentuk pelet, pasta dan campuran keduanya terhadap pertumbuhan benih sidat *(Anguilla bicolor). Prosiding Sumber daya Perikanan Sidat Trofik*, 55-58.

Elieh-Ali-Komi, D., & Hamblin, M. R. (2016). Chitin and Chitosan: Production and Application of Versatile Biomedical Nanomaterials. *I nternational journal of advanced research*, *4*(3), 411–427.

Fahrizal, A., & Ratna, R. (2018). Analisa proksimat pellet berbahan limbah ikan PPI Klaligi Kota Sorong. *Median: Jurnal Ilmu Ilmu Eksakta*, *10*(3), 31-38. https://doi.org/10.33506/md.v10i3.182

Febrianti, E., Wellem, H.M., Oce, A., Agus, K., Muhaimin, H., Yusnaini. (2019). Substitusi Tepung Ikan Dengan Tepung Maggot Dalam Pakan Terhadap Pertumbuhan dan Kelangsungan Hidup Udang Vaname (*Litopenaeus vannamei*). *Media Akuatika*, *4*(4), 168- 177. http://dx.doi.org/10.33772/jma.v4i4.10570

Goddard, S. (1996). Feed Management in Intensive Aquaculture. New York (US): 194 hal. Chapman and Hall.

Hadadi, A., Herry, Setyorini, Surahman, A., Ridwan, E. (2007). Pemanfaatan limbah sawit untuk bahan pakan ikan. *Jurnal Budidaya Air Tawar*, 4(1): 11-18.

Hariati, A.M. (1989). Makanan Ikan. Nuffic/Unibraw/Luw/Fish. Universitas Brawijaya. Malang. 155 hal.

Idris, A. P. S. (2016). Analisis berbagai kadar protein terhadap konsumsi dan efesiensi pakan pada budidaya ikan sidat (*Anguilla marmorata*). *Journal Galung Tropika*, *5*(2), 109-117. https://doi.org/10.31850/jgt.v5i2.168

Jamaluddin, J., Damayanti, A. T., & Widodo, A. Comparative Study of Vitamin C of Sidat Fish (*Anguilla Marmorata* (Q.)

Gaimard) Glass Eel Fase, Yellow Eel and Silver Eel From Poso Lake and Estuary of Palu River. *Ghidza*, *2*(1), 7-12. https://doi.org/10.22487/ghidza.v2i1.10256

Kardana, D., Haetami, K., & Suherman, H. (2012). Efektivitas penambahan tepung maggot dalam pakan komersil terhadap pertumbuhan benih ikan bawal air tawar (*Colossoma macropomum*). *Jurnal Perikanan Kelautan*, *3*(4), 177-184. https://jurnal.unpad.ac.id/jpk/article/view/2560

Lovell, T. (1989). Nutrition and feeding of fish. Auburn University. An A VI Book. New York (US): Publised by Van Nostrand Reinhold. 258 p.

Ministry of Marine Affairs and Fisheries. (2017). Description of Sidat Fish. http://bpsplpadang.kkp.go.id/deskripsi-ikan-sidat. Accessed on March 15, 2021.

Nawir, F. (2015). Kinerja Pertumbuhan Ikan Sidat Anguilla bicolor bicolor yang Diberi Pakan dengan Kadar Protein dan Rasio Energi Protein berbeda. Tesis. Sekolah Pascasarjana, Institut Pertanian Bogor, Bogor.

Panjaitan, J., Indra, S., Adelina. 2014. Effect of Different Substituted Fish Meal with Maggot Meal for Growth of Jambal Siam (*Pangasius hypothalmus*). *Jomfaperika*, *1*, 2, 1-7.

Priyadi, A. (2008). Pemanfaatan maggot sebagai pengganti sumber protein asal tepung ikan untuk pakan benih ikan balashark (*Balanthiocheilus melanopterus, Bleeker*). Laporan Penelitian Balai Budi daya Ikan Hias Depok.

Priyadi, A., Azwar, Z. I., Subamia, I. W., & Hem, S. (2009). Pemanfaatan maggot sebagai pengganti tepung ikan dalam pakan buatan untuk benih ikan balashark (*Balanthiocheilus melanopterus Bleeker*). *Jurnal Riset Akuakultur*, *4*(3), 367- 375. http://dx.doi.org/10.15578/jra.4.3.2009.367-375

Ritonga, T. (2014). Respon Benih Ikan Sidat *(Anguilla bicolor bicolor)* terhadap Derajat Keasaman (pH). Skripsi. Departemen Manajemen Sumberdaya Perairan, Fakultas Perikanan dan Ilmu Kelautan, Institut Pertanian Bogor, Bogor.

Rumondor, G., Maaruf, K., Tulung, Y. R. L., & Wolayan, F. R. (2016). Pengaruh penggantian tepung ikan dengan tepung maggot black soldier (*Hermetia illucens)* dalam ransum terhadap persentase karkas dan lemak abdomen broiler. *Zootec*, *36*(1), 131- 138. https:/

/doi.org/10.35792/zot.36.1.2016.10452

Safitri, A. (2014). Kinerja Pertumbuhan Ikan Sidat *Anguilla bicolor* Stadia Yellow Eel yang Diberi Pakan Pasta dengan Sumber Protein Berbeda. Skripsi. Departemen Budidaya Perairan, Fakultas Perikanan dan Ilmu Kelautan, Institut Pertanian Bogor, Bogor.

Samsundari, S., & Wirawan, G. A. (2013). Analisis penerapan biofilter dalam sistem resirkulasi terhadap mutu kualitas air budidaya ikan sidat (*Anguilla bicolor*). *Jurnal gamma*, *8*(2), 86– 97. https://ejournal.umm.ac.id/index.php/gamma/article/view/2410

Sukardi, P., Prayogo, N. A., Pramono, T. B., Sudaryono, A., & Harisman, T. (2019). Evaluation of Local Carbon Sources In The Biofloc System For Juvenile Pangasius pangasius Culture Using Small-Scale Plastic Pond In Central Java, Indonesia. *Aquacultura Indonesiana*, *20*(1), 48- 56. http://dx.doi.org/10.21534/ai.v20i1.146

Toiba, Y., Sabang, S. M., Tahril, T., & Aminah, S. (2022). Analysis of Fatty Acid Content of Eel (*Anguilla Bicolor*) from Lake Poso. *Media Eksakta*, *18*(2), 108- 114. https://doi.org/10.22487/me.v18i2.2349

Winarno, F.G. (1997). Kimia Pangan dan Gizi. Gramedia. Jakarta

Zonneveld, N., Huisman, J. H. Boom. (1991). Prinsip-prinsip Budidaya Ikan. Gramedia Pustaka Utama. Jakarta. 317 hal.